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SCIENCE ABSTRACTS.

Section A.—PHYSICS.

JANUARY 1922.

GENERAL PHYSICS.

1. *Open Mercury Manometer Used with Displacement Interferometer.* **C. Barus.** (Nat. Acad. Sci., Proc. 7. pp. 71–75, March, 1921.)—Describes an open mercury manometer consisting of two large mercury areas, communicating at the bottom, and each in a vessel closed above by a glass plate, but communicating with the air by means of a small tubulure. Reflection takes place, not from the actual mercury surface, but from a thin glass plate floating on it. By closing one tubulure the apparatus may be used as a very sensitive air thermometer. In this way it was found that the heating effect of the rays of light on the closed vessel was 2×10^{-4} deg. C. per sec. J. W. T. W.

2. *Recording Ultra-Micrometer.* **J. J. Dowling.** (Engineering, 112. p. 395, Sept. 9, 1921. Paper read before the British Assoc., Edinburgh, Sept., 1921.)—A description has previously been given of the apparatus employed [Abs. 719 and 757 (1921)]. Various applications of the method are now dealt with; these include the measurement of minute strains, expansions, displacements, etc., the measurement of minute variations in gravitational force, or in atmospheric pressure. A weighing device has also been developed for weighing 200 gm. to the nearest milligramme. A. W.

3. *Coradi's Polar Coordinatograph.* **A. Staerkle.** (Schweiz. Zeits. f. Vermess. u. Kulturtechnik, 19. pp. 13–33, 1921. Zeits. Instrumentenk. 41. pp. 273–274, Sept., 1921.—Abstract.)—There is in this instrument a circular table, on which a frame traces angles as it rotates in a circular groove on the table edge. On the frame is mounted another frame, which runs to and fro by a parallel movement on a linear scale. All movements are rendered free by rollers. The polar coordinates r, θ, are thus provided for the analysis or synthesis of curves. A photograph of the instrument is shown. P. E. S.

4. *The Vertical-Component Seismograph.* **S. Nakamura.** (Phys. Math. Soc. Japan, Proc. 3. pp. 101–107, Sept., 1921.)—Finding that the theories of Ewing and Galitzin on the vertical-component seismograph differ considerably, the author re-discusses the subject, and shows that the difference is due to neglect of the second and higher terms of the displacement; and a more complete expression is found. W. A. R.

5. *Fundamental Principles of Scientific Inquiry.* **D. Wrinch** and **H. Jeffreys.** (Phil. Mag. 42. pp. 369–390, Sept., 1921.)—It is shown that intensive theories of the structure of Nature which involve the use of infinite classes of entities of kinds known only by observation are not capable of yielding satisfactory accounts of the method by which we have acquired our knowledge of physics, and that the same applies to the theory of universal consent as a basis of scientific knowledge. The whole of a single person's knowledge is based upon a finite number of observations and his individual judgments, and the problem of a theory of scientific knowledge is to show how this can be carried out.

It is clear that such a theory must depend on the theory of probability, and the question of the probability of physical laws and of inferences based on them is discussed. It is shown that it will never be possible to attach appreciable probability to an inference if it is assumed that all laws of an infinite class, such as all relations involving only analytic functions, are equally probable *a priori.* If inference is possible, the admissible laws must not be all equally probable *a priori.* It is suggested that all admissible laws can be arranged in a well-ordered sequence, each having a finite prior probability, and such that each is more probable than any that follows it in the sequence. The probabilities of the laws must form a convergent series. On this basis it is shown that with sufficient empirical verification of a law the probability of further inferences from it will approach certainty.

There is reason to believe that all admissible laws must form an enumerable aggregate, and this condition, and apparently all others which are necessary, are satisfied if we suppose that all laws admissible in physics are expressible as differential equations of finite order and degree, with rational coefficients. The most natural ways of well-ordering these are such that those of low order and degree, and involving no numerical constants other than small integers and fractions with small numerators and denominators, come earliest in the sequence. Accordingly, the practice of adopting the simplest law that fits the available observations appears to be closely related to the possibility of a satisfactory theory of inference. AUTHORS.

6. *Limit of Application of the Gaussian Law of Errors.* **W. Bothe.** (Zeits. f. Physik, 4. 2. pp. 161–177, 1921.)—A mathematical discussion of the applicability of the Gaussian law in the case of independent sources of error. Tait considered the case of linear sources of error, while Rayleigh [see Abs. 521 (1919)] has also included the two- and three-dimensional problem. These authors have introduced correction terms into the simple Gauss equation, and the paper gives a further extension of the mathematical analysis of the problem. J. W. T. W.

7. *A Simple Extension of Fourier's Integral Theorem and some Physical Applications, in particular to the Theory of Quanta.* **R. H. Fowler.** (Roy. Soc., Proc. 99. pp. 462–471, Sept. 1, 1921.)—A gap is indicated in the argument of Poincaré, to fill which a limited extension of Fourier's integral theorem is developed. The mathematical considerations arising

are applied to the theory of quanta, and, tentatively, to the absorption of non-homogeneous beams of X-rays. A. B. C. L.

8. *New Revision of the Density of Gaseous Oxygen.* **E. Moles** and **F. Gonzalez.** (Comptes Rendus, 173. pp. 355–358, Aug. 8, 1921.)—The density of oxygen prepared either from potassium permanganate, potassium chlorate, mercuric oxide, or silver oxide, or electrolytically, has been measured by determining the weight of the gas contained in vessels of known capacity. The results of 45 measurements give for the density at 0°, 760 mm., sea-level and latitude 45°, the mean value 1·42889. The divergencies of the individual results from this mean are of the same order as those obtained by Morley, although the latter used volumes 30 times as great as those employed in the authors' measurements. T. H. P.

9. *Experiments on the Effects of Extremely High Pressures.* **T. W. Bridgman.** (Compressed Air Magazine, 26. pp. 10223–10225, Sept. 9, 1921. Am. Soc. Mech. Eng., J. 43. pp. 738–739, Nov., 1921.—Abstract.)—This paper contains data of an investigation in a field of which comparatively little is known, but in which the author has been working for several years. Pressures as high as 20,000 atmos. or about 300,000 lbs. per sq. in. (about 10 times as high as the explosion pressure in a large gun) have been used, and obtained by means of a patented device free from leakage. The author found that the engineering theories of the strength of vessels do not hold good at these high pressures. When a cylinder breaks, the crack starts on the outside, where the stretch and stress are presumably least, and travels towards the inside, where they are expected to be greatest. Pressure was produced by a small piston, driven by a hydraulic press, operated by a hand-pump. This pressure was transmitted through a connecting pipe drilled out of a solid bar. A modification of the dead-weight gauge was used, and as a secondary standard, one based on the change produced by pressure in the electrical resistance of a metal (manganin alloy). In general it was found impossible to force ordinary liquid into the pores of a metal, even at the above high pressures. However, hydrogen compressed to a pressure of 10,000 atmos. will eat its way through a massive steel container and blow out. Compressed air apparently behaves much like hydrogen, and can be forced through massive steel walls by about 60,000 atmos. pressure. Under high pressure, liquids were found to be comparatively highly compressible. By 12,000 atmospheres water can be compressed to 20 % less than its normal volume, and even metals showed appreciable compressions. Under sufficient pressure a liquid can be forced to freeze at temperatures substantially higher than its freezing temperature. Ice produced under a pressure of 2000 atmos. is about 18 % less in volume per unit of weight than natural ice, and sinks instead of floating in water. Water at 180° F. may be forced to freeze to this kind of ice by the application of about 20,000 atmos. At 12,000 atmos. and 200° C., phosphorus assumes a black form like graphite in appearance, loses its combustibility, becomes a conductor of electricity, and is 50 % denser than yellow phosphorus. H. H. Ho.

10. *Elastic Constants of Glass by Cornu's Method.* **H. T. Jessop.** (Phil. Mag. 42. pp. 551–568, Oct., 1921.)—Describes experiments on the variation with lapse of time of Young's modulus and Poisson's ratio for clear plate glass, using a slight modification of Cornu's method. The

apparatus used is described in the paper, and the results there tabulated show that with one exception a decrease of from 0·3 to 1·5 % in Young's modulus takes place after the load has been applied to the glass beam for 50 minutes. The width/thickness ratios of the beams varied from 4·5 to 9, and the max. stresses from 136 to 237 kg./cm.^{2}. J. W. T. W.

11. *Two-dimensional Stresses in Rectangular Plates.* **C. E. Inglis.** (Engineering, 112. pp. 523–524, Oct. 7, 1921. Paper read before the British Assoc., Edinburgh, Sept., 1921.)—Describes a general analytical method for the investigation of the distributions of stress set up in a rectangular plate by stresses applied along its edges in any given manner. The method depends on the analysis into Fourier series of the boundary distributions of the stresses, and, while needing considerable calculation, it provides a powerful and direct method of attacking the problem. By the use of curvilinear coordinates the problem of a plate with curved boundaries can be dealt with similarly. J. W. T. W.

12. *Elastic Theory for Two-dimensional Problem.* **K. Wolf.** (Zeits. techn. Physik, 2. 8. pp. 209–216, 1921.)—Gives a mathematical treatment of the problem of distribution of stress in the neighbourhood of (*a*) an elliptical hole, and (*b*) a crack, in a plate subjected to a straight stress in a single direction. The results obtained agree with those found by the optical method of studying stresses. The paper is mainly mathematical, and cannot be usefully abstracted. J. W. T. W.

13. *Percussion Figures in Isotropic Elastic Solids.* **S. Banerji.** (Calcutta Math. Soc., Bull. 12. pp. 93–96, Sept., 1921.)—Discusses the occurrence of fracture on percussion by aid of the figures due to H. Hertz and to S. Fuchs (both of which are reproduced), and to those due to C. V. Raman [Abs. 13 (1920)]. E. H. B.

14. *Elongation and Gauge Length in Tensile Tests.* **J. H. G. Monypenny.** (Engineer, 132. pp. 220–221, Aug. 26, 1921.)—The percentage elongation obtained in a tensile test on any given steel depends on the relative values of the length and cross-sectional area of the test-piece. This has been provided for in British standard specifications, and also in the standard specifications of other countries by the use of standard forms of test-pieces. In most specifications more than one size of standard test-piece is given, and in most cases the relationship between length and area is fixed by an equation of the form $L = K_1\sqrt{A}$ or $L = K_2D$, where K_1 and K_2 are constants. Unfortunately the values of these constants vary in the standards used by the several countries, and are given in the paper for Great Britain, France, Russia, Belgium, Germany, Austria, and U.S.A. The values for elongation on the same steel vary very widely when using standard test-pieces specified in the different countries. Examples are given showing elongation on varying gauge lengths in different test-pieces, and the results of a series of comparative tests, carried out on a large series of steels, are given to show the approximate relationship for commercial use between the values obtained on the British standard test-piece and the French and German types. It was found that steels could be grouped into two classes—(*a*) carbon steels and non-air-hardening alloyed steels when in the normalised or rolled condition; (*b*) carbon and alloy steels in the hardened and tempered condition. In each of the two groups the values of the ratio between the English and French or English and German test-pieces were approximately constant, but these ratios varied considerably between the two classes. The elongation on the British test-piece should be multiplied by the following figures to obtain the equivalent values on the foreign piece:

For normalised or rolled steels	French, 0·77	German, 0·69
For hardened and tempered steels	,, 0·69	,, 0·59

By a coincidence, the ratio between British and French test-pieces for hardened and tempered steels is the same as that between British and German for normalised steels. C. O. B.

15. *Influence of Width of Specimen on Tensile Tests of Metals.* **T. H. Beare** and **W. Gordon.** (Engineering, 112. pp. 389–391, Sept. 9, 1921. Paper read before the British Assoc., Edinburgh, Sept., 1921.)—Gives the results of experimental work carried out with a view of ascertaining the nature of the influence of the width of the specimen upon the apparent strength and ductility of mild steel and rolled copper under test. The yield-point remains practically constant over the range of observations on specimens varying from ¼ in. to 4 in. wide. The tenacity, or commercial max. stress, also appears to be little affected. In the case of extension the results are given for the British standard gauge length of 8 in. and for the German standard $11 \cdot 3\sqrt{(\text{area})}$. The variation of extension is very marked in the 8-in. gauge length; for the ¼-in. steel plate the extension being 22·29 % for the ½-in. wide specimen and 32·47 % for the 4-in. wide specimen. The variation is much less in case of the German gauge length, the max. variation for the ¼-in. steel being from 27·28 to 29·48 %. The results for reduction in area show a fall in value with increase in width of specimen. The actual measurements show that the final thickness is practically constant for all widths of specimen, the decline in the percentage of reduction in area being due to a gradual diminution in the proportional reduction of width. C. O. B.

16. *Attempt to reach high Instantaneous Pressure: Experimental Demonstration.* (Nature, 107. p. 377, May 19, 1921.)—At a conversazione of the Royal Society held in May 1921 an apparatus was exhibited by C. A. Parsons and S. S. Cook with which an attempt is made to reach high instantaneous pressure by the collapse of a hollow sphere of lead under external pressure suddenly applied by an explosive. The sphere is made up of two hemispheres placed together with tissue-paper between and soldered around the periphery of the joint. In the cavity is placed the substance to be compressed. If its final diameter in nuclear form is 1/200th that of the initial hollow, and the pressure of the explosive 20 tons per sq. in. the nuclear pressure produced is 1,000,000 tons. The explosive is fired in six places simultaneously. L. H. W.

17. *Origin of the Disturbances in the Initial Motion of a Shell.* **R. H. Fowler** and **C. N. H. Lock.** (Cambridge Phil. Soc., Proc. 20. pp. 311–319, May, 1921.)—A theoretical and experimental attempt to elucidate the cause of the initial angular oscillations of the axis of a (stable) spinning shell. [See Abs. 985 (1921).] L. H. W.

18. *Law of Fluid Resistance to Moving Bodies.* **C. Wieselberger.** (Phys. Zeits. 22. pp. 321–328, June 1, 1921.)—After a resumé of the pre-

vious work on this subject, the author gives the results of experiments on the resistance experienced by long cylinders of various diameters d (from 0·05 to 300 mm.) in moving air. He shows that for these diams. the coefficient c in the expression for the resistance, $\frac{1}{2}cF\rho v^2$, is constant only over the range 11,000 to 120,000 for the value of $\rho vd/\mu$, where μ is the viscosity, ρ the density of the medium, and v is the velocity.
J. W. T. W.

19. *Problems of Potential Theory.* **G. C. Evans.** (Nat. Acad. Sci., Proc. 7. pp. 89–98, March, 1921.)—The paper is devoted to the enunciation and development of various mathematical theorems arising in the study of potential theory, more particularly with reference to the equations of Laplace and Poisson and various forms of Green's theorem. In connection with the latter, a special double integration by parts is given. A. B. C. L.

20. *Study of the Movement of the Conical Pendulum by Means of a Screen.* **R. Serville.** (Comptes Rendus, 173. pp. 470–472, Sept. 12, 1921.)—Describes a further experiment with the apparatus referred to in a previous communication [see Abs. 1900 (1921)]. A. B. C. L.

21. *A Glossary of Named Effects and Laws.* **L. C. Krueger** and **H. R. Hosmer.** (Gen. El. Rev. 24. pp. 258–278, March, 1921.)—A list is given, arranged in alphabetical order, of the laws and effects which are usually associated with the names of the propounder or discoverer. A reference is given either to the original paper in which the effect was described, or else to some standard work where further information can be found. L. H. W.

22. *Theory of the Sliding and Rolling Resistance of Solid Bodies.* II. *Rolling Friction.* **S. Fuchs.** (Phys. Zeits. 22. pp. 213–218, April 1, 1921.)—This paper forms Part II of an investigation into the nature of sliding and rolling friction [see Abs. 1356 (1921)]. It treats specially of the second variety, the law for which was first formulated by Coulomb as $M = fP$, where M expresses the resistance moment which has to be overcome at any given instant, P is the normal pressure, and f a coefficient of rolling friction possessing the dimensions of length, and to be regarded as a surface constant. It has long been thought that f is not a material constant, but a function of the radii of curvature of the rolling body and surface beneath, and of the load P; this is now shown to be true when an elastic body rolls upon an elastic surface. Frictional phenomena are found to be analogous to magnetic hysteresis. The work and results of both papers are as follows:—I. The so-called *dry sliding friction* of solid bodies has its origin in the hydrodynamical friction of the air layer separating the bodies. From this physical standpoint the known empirical frictional laws may be explained. The hydrodynamic hypothesis also serves for the elucidation of the frictional phenomena between specially purified surfaces in an evacuated space. The observed dependence between the angle of friction and the velocity is expressed by an exponential function.

II. The *rolling resistance* of elastic bodies is arrived at by the assumption of a partial elasticity based on an approximation process. The rolling friction is shown to be dependent on the material constants, the curvatures of rolling body and surface, the load, and the rolling velocity.

The cause of slip during the rolling of elastic substances is investigated, and the ratio of sliding to rolling friction found for the case when the bodies are relatively hard. A study is also made of the influence due to mass distribution within the rolling body upon the magnitude of the resistance offered. H. H. Ho.

23. *Theory of Fluid Motions.* **P. Allbrandi.** (N. Cimento, 22. pp. 94–113, July–Aug., 1921.)—A contribution to the hydrodynamic theory of fluid movements. The paper is mainly mathematical, and cannot be usefully abstracted. J. W. T. W.

24. *Effect of Viscosity on the Flow through an Orifice.* **W. N. Bond.** (Phys. Soc., Proc. 33. pp. 225–230; Disc., 230, June, 1921.)—Determinations were made of the coefficient of discharge through an orifice 0·1469 cm. in diameter of solutions of glycerine and water, varying in kinematic viscosity from 0·01 to 7. The results are plotted in a manner which combines both purely viscous and purely turbulent flows in one graph. It is shown that the effect of slight viscosity is to increase the coefficient of discharge. AUTHOR.

25. *Viscosity of Water at Low Rates of Shear.* **A. Griffiths** and **C. H. Griffiths.** (Phys. Soc., Proc. 33. pp. 231–242; Disc., 242, June, 1921.)—Describes the determination of the coefficient of viscosity of water by a method in which water is forced along glass capillary tubes of about 1·5 to 2·0 mm. bore at rates of flow varying from 1 litre in 2 years to 1 litre in 24 years. The liquid fills a closed tubular circuit rectangular in shape. Two of the tubes of the rectangle are horizontal, and two vertical. The circulation is caused by a difference of density between the contents of the two vertical tubes. The difference is obtained by having a weak solution of uranine in one vertical tube, and pure water in the other.

In Apparatus I the two vertical tubes are at a distance apart, and an allowance has to be made for the difference of temperature. In Apparatus II a modification of the rectangular circuit is employed, the vertical tubes are close together, and no such correction is necessary.

Applying the temperature correction to the results, the value of the coefficient of viscosity at 18° C. is 0·010624 ± 0·000229 (assuming observations of equal weight) and 0·010569 gm./cm. sec. from Hosking's formula. Thus there is no experimental evidence that at the extremely low rates of shear (0·0017 to 0·0233 radians/sec.) the viscosity of air-free water in glass capillary tubes differs from its value at normal rates of shear (5000 to 10,000 radians/sec.). AUTHORS.

26. *On the Absorption of Gravitation.* **Q. Majorana.** (Comptes Rendus, 173. pp. 478–479, Sept. 12, 1921.)—This follows his former paper on this subject [see Abs. 802 (1920)], in which the author disclosed that a screen of mercury placed round a lead mass reduced the weight of the latter by about 1,1000 mgm. In the present case a cube of lead, of 95 cm. side, is built round the mass suspended from the balance. The result was a diminution in weight by 2/1000 mgm. The first determination gave an absorptive coefficient per unit density and per unit length of $6\cdot7 \times 10^{-12}$, whereas the coefficient in the present case is $2\cdot5 \times 10^{-12}$. The author does not know whether to attribute this difference to an experimental error in the first measurements, or to an error in his theory. He trusts to further experiments to clear up the point. In yet another series of experiments the suspended lead mass is placed above his large lead cube, with the result that the Newtonian attraction of the cube appears to be 2/10 mgm. When the suspended mass is placed below the cube the gravitative attraction is less than in the other case by 4/1000 mgm. The author does not know which of the two last values ought to be used for determining the Newtonian constant. At present he prefers to take the mean value and eliminate systematic errors. But as regards the absorptive power of the lead, his three determinations are consistent with one another—the whole mass absorbing twice as much as the lower half of it did in the first case. P. E. S.

27. *The Static Gravitational Field.* **K. Ogura.** (Comptes Rendus, 173. pp. 521–523, Sept. 26, 1921.)—The subject is treated mathematically, the conditions being investigated on the basis of Einstein's law of gravitation, for a typical case. A. B. C. L.

28. *Space-Time Symmetry.* **N. H. Kolkmeijer.** (Phys. Zeits. 22. pp. 457–466, Aug. 15, 1921.)—This paper is a summary and extension of considerations recently published on space–time symmetry [see Abs. 772 (1921)]. As soon as the motions of the constituent parts of a geometric symmetrical structure are considered, the three-dimensional idea of space-symmetry can be generalised to the four-dimensional space–time symmetry. In referring to the existence of the binding-ring in the diamond, the author had occasion to make certain assumptions on the motions of the electrons in these rings. These confer on the carbon atom in the diamond a definite R.Z. symmetry. In support of this view is the presentation by Landé and Madelung of an R.Z. symmetrical structure for the general nucleus-electronic configuration of the atom. The success of the Sommerfeld ellipse hypothesis is, again, an example of the utility of R.Z. symmetrical considerations with respect to atomic structure. Section 1 of the paper deals with the R.Z. operations; section 2 with the group of pure Z.-Δ; section 3, with the groups of R.Z.Δ, which contain no Δ associated with τ. A table is given of the groups of the space–time operations without translations. The paper is mathematical throughout. [Errata, *ibid.* p. 519, Sept. 15, 1921.] H. H. Ho.

29. *Rotating Reference System in a Minkowski World.* **F. Kottler.** (Phys. Zeits. 22. pp. 274–281, May 1, 1921.)—Recently [see Abs. 853 (1916)] space–time measurements in rotating systems of reference have given rise to frequent discussions on the general theory of relativity. This has caused the present author to communicate his investigations respecting a generalisation of the Lorentz transformation for certain accelerated motions, which work was in progress before the formulation of the general theory of relativity. The present paper deals more particularly with uniform rotation. In Section 1, a uniform rotating reference system is given in fixed stellar space, whose own mass may be neglected. According to the general theory of relativity, this system is in a Minkowski world, since all masses are infinitely removed from it. It is shown that neglect of the special mass of the system is permitted with the same right, or otherwise, as that by which the mass of a test body may be neglected in a gravitational field. Section 2 deals with possible changes of the dynamic specification of the electronic system. Section 3 discusses the Ehrenfest and Einstein paradoxes. In section 4 it is shown that on the basis of natural space–time measurements, a unit space–time measurement cannot be constructed. Section 5 considers the natural measurement of time, and section 6 its connection with that of space. The conclusion is drawn that the natural space and time measurements are inapplicable for a unit space–time measurement in the rotating system, and the mathematical basis of this inapplicability is given in section 7. An artificial derivation of such a space–time measurement is sought for in section 8, the discussion of which is continued in section 9, and its mathematical representation given in section 10. In conclusion the author remarks that Einstein has employed the paradox quoted in section 3, in order to draw the conclusion that, in general, the gravitational field influences the space measure to such a degree that geometry is no longer Euclidean. Then as a consequence of his equivalence hypothesis, processes in the rotating system are equivalent in a determined gravitational field termed by the present author a gravitational rotation field. The conclusion drawn by Einstein is only valid, however, when the result of the natural space measurement is designated as geometry. For the space-like part of the four-dimensional measurement ds^2, the Einstein conclusion is invalid. The rotating system can, therefore, furnish no example for the influence of the space-like part of ds^2 by actual gravitational fields, as appears in the field of the mass point (Schwarzschild). H. H. Ho.

30. *An Elementary Geometrical Representation of the Transformation Formula of the Special Theory of Relativity.* **P. Gruner.** (Phys. Zeits. 22. pp. 384–385, July 1, 1921.)—The various geometrical representations of the Lorentz transformation utilise either rectangular systems of coordinates with imaginary angles of rotation (i.e. imaginary time coordinates), or acute-angled coordinate systems with real dimensions, by which, however, the units are different for every axis, and must be first determined by the Minkowski unit hyperboloid. To instil into the beginner a comprehension of the relativity theory a geometrical representation is desirable, in which neither imaginary magnitudes nor different units occur. Such a representation is easy to establish when the limitation is composed of only two uni-dimensional space coordinates. This is neatly demonstrated in the paper. H. H. Ho.

31. *Gravity and Inertia.* **E. Reichenbächer.** (Phys. Zeits. 22. pp. 234–243, April 15, 1921.)—Many objections have been raised against Einstein's general theory of relativity, and since Einstein based his explanation of gravitation thereon, the present author recently asked the question as to how far modern gravitational theory could be derived without recourse to the relativity hypothesis. In his reply Einstein only partially met the author's standpoint, that, apart from matter, independent gravitational fields are impossible. Reference is made to Kottler's example of the so-called gravitational field of rotation in the interior of a uniformly rotating homogeneous hollow sphere [see Abs. 1213 (1918)]. The equivalence principle is discussed in detail, and the author suggests its replacement by an Identity Principle, which can be extended to the case of the general gravitational field. He rejects the conception that a gravitational field can be produced merely by a change of coordinate system, and asserts that a confusing of gravitational and acceleration fields is only possible when total experience is not taken into account, especially electromagnetic (light) effects. In the cosmos only gravitational fields exist. In section 2, the problem of uniform rotation is discussed, together with the mixing of Einstein's theory and the older relativity theory propounded by Mach. Section 3 deals with Kopff's treatise on the rotation problem in the relativity theory. The assumptions of the finite character of space and the approximately uniform distribution and static nature of matter are criticised in the final paragraphs. The author concludes that the impression produced by a consideration of the various objections raised is that the general theory of relativity has not been established—firstly, on account of contradictions within; and secondly, by the existence of gravity.

[Errata, *ibid.* p. 344, June 1, 1921.] H. H. Ho.

32. *Relativity Theory.* **O. J. Lodge.** (Nature, 107. pp. 716–719, Aug. 4; 748–751, Aug. 11; 784–785, Aug. 18, and pp. 814–818, Aug. 25, 1921.)—In continuation of his contribution to the Relativity Symposium in *Nature* [Abs. 1201 (1921)], the author discusses more fully and expresses in simplified form points treated by philosophical exponents of Einstein's theory. Einstein's fundamental assumptions in what Eddington calls "restricted relativity" are: (1) The essential impossibility of directly observing our absolute motion through space, whether accepting or rejecting the existence of the ether; and (2) the absolute constancy of the velocity of light for all observers. The latter is essentially a reassertion of (1). Both are certainly consistent with the Larmor-Lorentz transformation when the factor β, expression of the Fitzgerald-Lorentz contraction, is included; but they are not, as often claimed, necessary consequences thereof. Neither is it true that they have been established by experiment as is often asserted, *e.g.*, in Haldane's "Reign of Relativity," p. 82. And the transformation equations do not necessarily substantiate general conclusions as to the nature of time, or space, or ether. The equations show that to a moving observer time as well as distance must be considered variable. Einstein's step was equivalent to assuming all such local times to be equally real, and following up the consequences. The author then shows in detail how, waiving any question of experimental impracticability, and proceeding in an ideal fashion, the value of β, and consequently the transformation equations, can be derived, in the simplest and easiest fashion, from Einstein's assumptions. Calling t the time of passage of light as timed by a stationary observer at distance x, and t' and x' the corresponding (smaller) values of t and x when the observer is approaching the source with velocity u, the author summarises his detailed argument as follows:—"Assume that you cannot help measuring the same speed of light, whether you be moving or stationary, so that x/t and x'/t' both equal c; then allow that x/t' is not equal to $c + u$, as you would expect, nor x'/t equal to $c - u$ (for in that case xx'/tt' would equal $c^2 - u^2$ instead of c^2), but that, instead, $x/t' = \beta(c + u)$ and $x'/t = \beta(c - u)$, which, together, require that $\beta^2 = c^2/(c^2 - u^2)$; then the transformation follows."

A customary and older interpretation of the introduction of β is that the measuring rod by which x or x' is supposed to be measured shrinks to $1/\beta$ of its normal length if the experimenter moves to or fro with speed u, so that distances in the direction of motion are recorded as too great, and the same thing happens to the time-measuring instrument. Hence, while both distance and time are abbreviated by approach and lengthened by recession, the decrement is less and the increment greater than would be shown by unchanging measuring instruments. The ratio between measurements made during uniform approach and the same made during relative rest is $x'/x = t'/t = \beta(1 - u/c) = (c - u)^{1/2}/(c + u)^{1/2}$. These equations, with the definition $c = x/t$, provide the briefest possible summary of the transformation equations, β being self-defined as $\beta^2 = c^2/(c^2 - u^2)$, as before.

If now we seek to superpose a velocity $v = dx'/dt'$ on the speed u, and reckon the result as $dx/dt = w$, we do not find, as we might expect, $w = u + v$, but $w = (u + v)/(1 + uv/c^2)$, in which β is implicitly involved, in that without it we should not have the reciprocal equations which permit simple reversal of sign when the observer reverses his motion. The consequences of this law of composition of velocities include, among them the uniqueness and maximal character of the velocity c. The additional assumption of Einstein's generalised theory is that, (3) no distinction can be drawn between an artificial field or force, such as that representing the effect of a carefully defined revolution about a centre, and what we think of as a real field of force, such as that surrounding the earth. He calls it "the principle of equivalence." With this addition the theory predicts, without further hypotheses, a number of phenomena, in nearly all of which the experimental results have been differently expressed, all the expressions being in agreement with the electrical theory of matter, and probably the remainder may be similarly expressed. The assertion of (3) modifies (2) by making it applicable only to regions of space distant from matter. The Larmor-Lorentz equations were originally limited to the small range of u/c that covered all practicable observations. Einstein simply assumes that they, and consequently (2), hold good for all values of u, even for $u = \infty$. The constancy of light velocity in free ether is generally admitted, as otherwise it would depend on wave-length, making the ether coarse-grained. But that an observer approaching a source of light with speed u, and therefore approaching the wave-front with speed $u + c$, should obtain on measurement a speed $(c + u)/(1 + cu/c^2) \equiv c$, is curious, not to say paradoxical. While motion of the source does not affect speed, if a moving source emit waves at constant frequency n, the wave-length should vary with the direction θ, and this modified wave-length, $\lambda' = (c \cos \epsilon + u \cos \theta)/n$, can be observed by a fixed observer, and, when compared with the normal $\lambda = c/n$, is called the Doppler-effect. The small aberration angle ϵ, between ray and normal to wave-front, is defined by $c \sin \epsilon = u \sin \theta$. If the source be fixed in the ether and the observer moving, n varies, u and λ remaining normal, and we have an observable Doppler-effect $n' = (c \cos \epsilon + u \cos \theta)\lambda$ to be compared with $n = c/\lambda$. If source and observer drift through a medium, retaining a constant distance apart, $n\lambda' = n'\lambda$, so there is no Doppler-effect. But this is not so for relative motion between source and observer. Consider relative recession and write $u/c = \alpha$, then the observed frequency ratio will be, for source only moving, $n'/n = \lambda/\lambda' = 1/(\cos \epsilon + \alpha \cos \theta)$; and for receiver only moving, $n''/n = \cos \epsilon - \alpha \cos \theta$. Hence $n''/n' = 1 - \alpha^2$, which is the square of the usual Fitzgerald contraction. The relativity doctrine, to avoid recognising a difference, would presumably distribute this factor between the two expressions, making them $\lambda'/\lambda = (\cos \epsilon + \alpha \cos \theta)/(1 - \alpha^2)^{1/2}$ and $n''/n = (\cos \epsilon - \alpha \cos \theta)/(1 - \alpha^2)^{1/2}$, giving $n''\lambda' = n\lambda$. The introduced β factor cannot in this case be attributed to Fitzgerald contraction of the grating, this being normal to the incident light. Also the law of reflection is interfered with by the motion [Lodge, Roy. Soc. Phil. Trans. 184. pp. 793–800, 1893].

The author suggests that results amenable to observation might well be obtained. He asks why should Einstein's composition formula be accepted for light and not for such cases as ship and tide, satellite and planet, and railway train and embankment? The answer is that the formula is based on the transformation equations, and to treat its agreement with them as substantiating Einstein's hypotheses, upon which to found them would be reasoning in a circle. He considers it dangerous to adopt a mode of exposition which denies reality to the Fitzgerald contraction, and that still more is it premature to assume (1), carrying the implied assumption that the ether is non-existent, so that all motion can be treated as a purely geometrical or kinematical relation. Generally, he stresses the view that the relativity method, like that of least action, is to be regarded as an indirect attempt to treat all material phenomena as unknown essential features of one universal medium. He regards its comprehensive scope with its infinitesimal continuity of treatment as hopeful and encouraging; and the highly abstract and symbolic modes of representation as the tribute to our ignorance of the kind of dynamics appropriate to a substance the properties of which must be more fundamental than any we are likely as yet to have encountered among its sensory derivatives, electricity and matter. He also utters a word of warning to the non-mathematical philosopher and incautious exponent against being led into paradox by accepting illustrations employed by mathematicians under rigidly defined and perfectly understood limitations, and omitting to take these limitations into account. In this connection he refers to the preposterous attempts to eliminate the idea of absolute rotation by imitating and replacing centrifugal reaction by the influence of the stars, or by an imaginary distribution of attracting matter in distant space, round the earth or other rotating bodies. G. W. de T.

33. *Einstein's Great Achievement.* **O. J. Lodge.** (Fortnightly Review, pp. 353–372, Sept. 1, 1921.)—This paper is a brief summary of the contributions of Einstein and his chief predecessors to the relativity theory. The author maintains that the view that Einstein's theory destroys the ether is the contrary of the true interpretation. His law of composition of velocities is no longer a purely kinematic relation between points moving in empty space, but a physical or dynamical relation adapted to bodies moving through an ether. The fact that the characteristic ether-speed c enters into the expression shows that the ether is involved—for otherwise there could be no meaning in introducing the speed at which ether waves and other disturbances travel—and the only reason the ether speed can enter into the composition of velocities of two pieces of matter is that it is the medium through which both move. If we were concerned only with the relative speed of two bodies in empty space, moving with velocities u and v, any introduction of a third velocity, c, would be irrelevant and unmeaning. G. W. de T.

34. *Reply to H. Dingler's Criticism of the Relativity Theory.* **H. Reichenbach.** (Phys. Zeits. 22. pp. 379–384, July 1, 1921.)—Recently H. Dingler has asserted that the basic ideas of the relativity theory are unsound [see Abs. 359 (1921)]. The following paper demonstrates the existence of decisive errors in Dingler's argument, which as a consequence becomes untenable. Section 1 discusses the well-known example of the accelerated railway carriage. Section 2 deals with Dingler's consideration of the state of motion of the inertial system of the universe apart from its rotation through its relationship to the totality of the fixed stars. By gradual astronomical approximation Dingler then deduces the Galileo law of inertia. This result is disproved by introducing the differential principle of Einstein in place of the Newtonian integral principle. The Dingler standpoint is shown to be a mixture of that of Mach and Newton. Section 3 discusses simultaneity. In section 4 it is pointed out that Dingler has not recognised the assertion that the relativity theory may be ratified empirically. Dingler's defence of the opinion that against the validity of geometry no empirical decision can be found, is considered in section 5, and the invalidity of Euclidean geometry in natural coordinates demonstrated. The author lays stress on the need for a restatement of physical axioms. H. H. Ho.

35. *The Lorentz Transformation.* **L. A. Pars.** (Phil. Mag. **42.** pp. 249–258, Aug., 1921.)—The object of the paper is to show that it is not necessary to *assume* that there is a velocity c, invariant for the two systems of space-time measurement which are being considered, but that this follows from the hypothesis of relativity. According to this hypothesis the transformations relating to different observers must be consistent among themselves, so that the transformation from the space and time of observer A to that of B, followed by the transformation from B to C, must be equivalent to the direct transformation from A to C.

For the particular problem to which the Lorentz transformation applies the following two conditions have to be introduced:—(1) Space and time are isotropic and the equations of transformation are linear; (2) Two observers agree as to the measure of their relative velocity. If every pair of observers agree as to their relative velocity the measure of velocity for each observer becomes definite as soon as the measure of one velocity for one observer is prescribed, provided that a reversal of the direction of the axes for each of three observers, A, B, and C, does not affect the numerical value of the resultant of any two of the relative velocities; or the law of composition of velocities is commutative.

Let x, t be A's system, and x', t', x'', t'' those of B and C. Then the relation of x, t to x', t' is of the form $x' = \alpha(u)x + \beta(u)t$, $t' = \gamma(u)x + \delta(u)t$; where u is the relative velocity of B with respect to A, and α, β, γ, δ are functions whose form is to be determined. Since the space is isotropic the transformation must remain the same if we change the sign of x, x', u, but not of t, t'; thus α, δ are even functions and β, γ odd functions of u. Writing $x' = 0$, $x = ut$, whence $\beta(u) = -u\alpha(u)$, and $x' = \alpha(u)(x - ut)$. Similar expressions with the same coefficients α, β, γ, are obtained for x'', t'' in terms of v the velocity of C relative to B, and of U, the velocity of C relative to A, where $U = f(u, v) = f(v, u)$. It is shown that in order that the above expressions may be consistent, $u\alpha(u)/\gamma(u) = v\alpha(v)/\gamma(v) = \ldots = -c^2$, a real constant, and $\alpha(U) = \alpha(u)\alpha(v)(1 + uv/c^2)$ and $U\alpha(U) = \alpha(u)\alpha(v)(u+v)$. Thus $U = f(uv) = (u + v)/(1 + uv/c^2)$. In the expression for $\alpha(U)$ put $v = -u$, then $\alpha(0) = \alpha(u)^2(1 - u^2/c^2)$. Put $u = 0$, then $\alpha(0) = \{\alpha(0)\}^2$, or $\alpha(0) = 1$. Thus $\alpha(u) = (1 - u^2/c^2)^{1/2} = \lambda(u)$, and

$\gamma(u) = -\frac{u}{c^2}\lambda(u)$. Thus the transformation is $x' = \lambda(u)(x - ut)$, $t' = \lambda(u)(t - ux/c^2)$, which is the transformation of Lorentz. If γ is zero, c is infinite, and we get the Newtonian transformation. The Fitzgerald contraction and the invariance of the velocity c follow at once from the transformation. It follows from the value obtained above for U that the resultant of any number of velocities less than c is itself less than c. c is thus an upper limit to the velocity of moving bodies.

The transformation of the electromagnetic vectors can be obtained by similar reasoning, a linear transformation being obtained which leaves Maxwell's equations unchanged in form, with very simple assumptions, such as that the space is isotropic, that the electromagnetic components in B's system E'_x, E'_y, E'_z, H'_x, H'_y, H'_z are linear functions of E_x, E_y, E_z, H_x, H_y, H_z, the corresponding components in A's system, and that both observers choose the same unit of charge. Advantage is taken of the fact that the equations of transformation remain unchanged in form when the signs of E_y, E_z, H_y, H_z, and the corresponding accented components are changed, but not those of E_x, H_x; that the equations do not change with rotation through one right angle about the x axis, changing E_y, E_z, H_y, H_z into $E_z - E_y$, $H_z - H_y$; and that E'_z does not depend on H_x. With these assumptions the transformation equations $E'_x = E_x$, $H'_x = H_x$, $E'_y = \lambda(E_y - u/cH_z)$, $H'_y = \lambda(H_y + u/cE_z)$, $E'_z = \lambda(E_z + u/cH_y)$, and $H'_z = \lambda(H_z - u/cE_y)$ are obtained which give the familiar Lorentz-Einstein transformation. It is also shown that the transformation of a density of charge c having a velocity component v parallel to x in A's system is given by $\rho'/\rho = \lambda(1 - uv/c^2)$. H. N. A.

36. *Note on the Basis of the Theory of Relativity.* **K. Wessely.** (Phys. Zeits. 22. pp. 310–312, May 15, 1921.)—The present paper, which is mathematical throughout, first considers the duration of a motion. Two equations are derived for the constant velocity of an expanding sphere, whose geometrical significance is indeterminate and different according to the phase displacement which comes into consideration in the definition of place-time. Concentric spherical surfaces are only represented by the equations when this phase difference is zero. The author then proceeds to discuss the motion of a rigid body and the Doppler principle. The paper concludes with a note on the determination of the dependence of mass on velocity. H. H. Ho.

37. *Vector Algebra in General Relativity.* **C. E. Weatherburn.** (Tôhoku Math. J. 19. pp. 89–104, May, 1921.)—The theory of general relativity was developed by Einstein with the aid of the absolute differential calculus of Ricci and Levi-Civita. All subsequent writers on the subject have followed his example in the use of this calculus. It is the purpose of the present paper to give a presentation of the algebra of Einstein's covariant and contravariant vectors along the lines of matrices and ordinary vector analysis, in the hope that this will provide a more attractive approach to the theory of general relativity than the calculus of Ricci and Levi-Civita. AUTHOR.

38. *Units and the Relativity Theory.* **T. J. I'a. Bromwich.** (Phil. Mag. 42. pp. 431–432, Sept., 1921.)—In response to G. Greenhill's request [Abs. 1537 (1921)] for an explanation of what some writers on relativity mean by their statement that the sun's mass is equal to 1·47 kilometres, the author, without desiring to express any opinion on the value of the relativity theory, and remarking on the almost inevitable confusion resulting from the use of these special types of units by inexpert mathematicians, explains the origin of this apparently mystical result being claimed. Treating the earth's orbit as a circle of radius a, described in periodic time T, with S as the sun's mass and γ as the gravitation constant, we have $\gamma S/a^2 = a(2\pi/T)^2$, or $\gamma ST^2 = 4\pi^2a^3$. Then, if c be the speed of light, $\gamma S/c^2 = 4\pi^2a^3/(cT)^2 \ldots (1)$. On inserting the usual astronomical data, the value of the length on the right-hand side of (1) is found to be approximately 1·47 km. Accordingly, if the units be chosen so that the two fundamental constants γ and c are both expressed by unity, the mass of the sun will be expressed as 1·47 km. The author points out that the calculation is given in substance in A. S. Eddington's Report on Relativity (footnote on p. 27), but seems to have escaped notice to some extent, and mentions that a more exact form of (1) is really $\gamma(S + E)/c^2 = 4\pi^2a^3/(cT)^2$, where $2a$ is the major axis of the earth's orbit and E is the earth's mass. G. W. de T.

39. *Theoretical Appendix to Some Recent Observations on the Theory of Relativity.* **M. v. Laue.** (Phys. Zeits. 22. p. 332, June 1, 1921.)—In connection with the theory of the red-ward displacement of the spectral lines, the author has recently [see Abs. 419 (1921)] put forward a proof that in a coordinate system with the dimensional relation

$$d\tau^2 = V^2 dx^{4^2} - \sum_{ik=1}^{3} V_{ik} dx^i dx^k,$$

so long as the coefficients V and V_{ik} are independent of $t = x^4/c$, the light-waves in empty space undergo no change in propagation. When this is considered from the standpoint of the equation of approximation developed in the previous paper, the question arises as to whether the proof is sufficiently exact in view of the smallness of the displacement effect. An alternative method of proof is now communicated, based on the strictly valid wave-equation. H. H. Ho.

40. *On the Active Function in the Weyl Physics.* **R. Weitzenböck.** (Akad. Wiss. Wien., Ber. 129. 2A. No. 7. pp. 683–696, 1920.)—The invariant theory has recently come into great prominence through the development of relativity. The chief physical laws, namely, field laws and conservation hypotheses, have been deduced in the classical investigations of Mie, Hilbert, Einstein, Klein, and Weyl from a variation principle, $\delta\int W dx = \delta\int W dx_1 dx_2 dx_3 dx_4 = 0$, where W is the Hamiltonian or active function, and, by certain simplifications, a function of the state dimensions, g_{ik} $\partial g_{ik}/\partial x_a$, $\partial^2 g_{ik}/\partial x_a \partial x_\beta$, ϕi, $\partial\phi_i/\partial x_k$ has been found, in which the g_{ik} are the components of the metrical fundamental tensors, and the ϕ_i denote the components of the electromagnetic potential. In the present paper a proof is advanced that the active function W is an invariant of the four following tensors: g_{ik} the metrical fundamental tensor, ϕ_i the electromagnetic potential, Φ_{ik} the covariant derivative of ϕ with respect to g_{ik}, and $G_{ik,lm}$ the Riemann-Christoffel curvature tensor of the g_{ik}. From the tensor Φ_{ik} is derived the alternating tensor $\Phi_{ik} - \Phi_{ki} = f_{ik} = \text{rot}\ \phi$, which gives the electromagnetic field, and whose special enumeration as fifth tensor affords great advantage for calculations. It is further shown that on the basis of the Weyl metric the scope for the

active function W is essentially more limited, and in place of the above four tensors there are the three, namely: g_{ik} the metric fundamental tensor, f_{ik} the electromagnetic field, and $F_{ik,\,lm}$ the curvature direction.
The paper is mathematical throughout. H. H. Ho.

41. *The Brownian Movement in Gases.* I. *New Experimental Investigation.* **E. Schmid.** (Akad. Wiss. Wien., Ber. 129. 2A. Nos. 9 and 10. pp. 813–860, 1920.)—Following the theoretical investigations of the Brownian movement by Einstein and Smoluchowski, which led to identical results by quite different methods, a quantitative investigation was undertaken by Ehrenhaft for gases. Smoke and silver particles were observed in air and the animation of the Brownian movement was found to be of the character expressed by the Smoluchowski formula. De Broglie endeavoured to photograph the paths of the particles, but this was limited to definite dimensions, although in a succeeding investigation [see Abs. 1629 (1909)] he utilised this method for determining the magnitude and charge of smoke particles. The paper contains a review of work by Weiss, Millikan, Fletcher, Ehrenhaft, Parankiewicz, and Snethlage. One group of authors assert that the motions of particles due to the resistance laws and to the Brownian movement are in complete agreement with those of spherical-shaped objects of given density. The second group of authors find both motions to deviate from each other, and for metals and oil in opposed directions. A recent investigation on mercury and oil particles by Fürth appears to support Ehrenhaft.

The present paper has for its object a new experimental investigation, suggested by Ehrenhaft, of the apparent dependence of the Brownian movement on the masses of the particles by using substances of average density. Jäger has investigated the subject theoretically, and finds only very small dependence upon mass. A full description of the experimental arrangements is given, following which comes a calculation of the vertical and horizontal displacement squares with accompanying investigations of possible errors. This part of the paper is mathematical. The experimental data are then discussed at great length, tables of results being included. Selenium was the substance chosen, and this was sublimed in a slow current of nitrogen. By variation of the mode of heating particles of different dimensions could be produced. The particles could be charged by means of a radio-active preparation, and the times of descent and ascent in gravitational and electric fields respectively were ascertained. The non-dependence of the Brownian movement on external forces was established by comparison of the vertical and horizontal squares of displacement. An appendix is included, containing very complete apparatus details. H. H. Ho.

42. *The Exit Probability of Colloidal Particles and Related Ideas.* **E. Buchwald.** (Ann. d. Physik, 66. 1. pp. 1–24, Oct. 27, 1921.)—The elucidation of the phenomenon of concentration fluctuation deals with two problems—namely, its magnitude and velocity. The former is relatively easy to handle, and was solved some time ago; the latter and the much more difficult task has recently been solved by Smoluchowski. The last author introduced the new idea of probability after-effect, which could also be termed coupling-probability, and this is found to play an important part in the mechanism. If the particles in a definite volume v of a colloidal solution be counted after equal time-intervals τ, then it

follows from elementary considerations, when τ is sufficiently great, that $\overline{\Delta^2} = 2\nu$, where Δ is the difference of consecutive numbers of particles and ν the average number. When τ, however, is chosen sufficiently small, then a definite probability arises that a particle once counted shall remain within the volume v for the next observation, and this probability between the separate numerical values operates so that the average Δ is smaller than in the independent case. Accordingly $\overline{\Delta^2} = 2\nu P$, where P expresses the probability that a particle originally in v shall be absent after a time interval τ. The present paper deals with the application of this theory to a selenium hydrosol, a cylindrical volume being employed. The experimental details are given in full, and several tables of data included. Section 1 investigates the number of particles in a volume v at equi-distant time points, and compiles a statistical series for the expression $\overline{\Delta^2}/2\nu$. The Smoluchowski theory demands equality between the above expression and the probability after-effect P, but a systematic deviation has here been disclosed. In section 2 as in section 1, any initial situation of the particle in v is taken, and the exit probability P_2 investigated for the particles. Theory and experiment are found to agree. A value for the probable duration of stay T_2 follows from P_2. Like all events which are distributed not according to pure chance, but are related to the time axis, the average time T_1 has to be distinguished from T_2. The expression is found in section 3 for the exit probability P_1, i.e. the probability that an entering particle will again leave within the interval τ. Equations are derived for P_1 and T_1, which are proved by experiment, and the difference between T_1 and T_2 is established. Finally the probability is found in section 4, that a particle may not be present τ seconds after its entry. The paper combines experimental with highly mathematical treatment.
H. H. Ho.

43. *Crystal Formation by Directed Vapour Molecules.* **M. Volmer.** (Zeits. f. Physik, 5. 1. pp. 31–34, 1921.)—The phenomena described in this paper were first observed during experiments on the evaporation of crystals. This investigation was undertaken to establish whether the emergence of the structure from the lattice was conditioned by certain directional laws without an isotropic intermediate state. A clear result was not obtained on account of disturbing surface layers and retardation of the separating material which hindered correct observation. Notwithstanding these difficulties, however, an observation was recorded pointing apparently to a reversal of the above assumption, namely: a preferential arrangement of the crystal according to the direction of the molecules concerned. A series of decisive experiments are now described using cadmium, zinc, sulphur, mercuric iodide, and arsenic. A distillation method was adopted in which a hydrogen current moving with a velocity of 2000 cm./per sec. could be applied. The best results were obtained with cadmium and zinc. If crystal formation be regarded as a special case of the valency behaviour of atoms or molecules, then the assumption appears justifiable that similar directional influences may also be found between crystals and foreign chemically reactive molecules, a knowledge of which would be of great interest for the comprehension of the mechanism of chemical union. H. H. Ho.

44. *Crystalline Structures of Sputtered and Evaporated Metallic Films.* **H. Kahler.** (Phys. Rev. 18. pp. 210–217, Sept., 1921. Abstract of paper read before the Am. Phys. Soc., Dec., 1920.)—*Crystalline structures of evaporated films of bismuth and silver* condensed on a cool surface, were determined by the X-ray powder method. The films were found to contain no pure metal in the crystalline state, but to consist of amorphous metal and of metallic compounds. Optical evidence indicates that *selenium* also condenses on a cool surface in the amorphous form, although on a heated surface crystals are deposited whose size and colour depend on the temperature.

Crystalline structures of sputtered films of bismuth, cobalt, gold, platinum, and silver, as determined by X-ray analysis, were in each case the same as that of the unsputtered metal. The crystal grains had a random distribution of axial direction. Evidently in sputtering crystalline grains are knocked off the kathode and are transported and deposited grain by grain, whereas evaporation takes place atom by atom.

Relative Sputtering of Hexagonal and Cubic Forms of Cobalt.—The hexagonal form is easily sputtered, whereas the other form is not.

The *crystalline structure of bismuth,* determined by X-ray analysis of the powdered metal and sputtered film, is rhombohedral trigonal, with elementary triangular prism of side 4·54 Å. and height 5·91 Å.

AUTHOR.

45. *Methods of Arranging Elementary Crystals.* **K. Becker, R. O. Herzog, W. Jancke,** and **M. Polanyi.** (Zeits. f. Physik, 5. 1. pp. 61–62, 1921.)—The authors show that elementary crystals in powders and apparently non-crystalline materials can be " arranged " with their axes in a definite direction by the following methods :—

(1) If a crystalline powder is brought into a strong magnetic field the elementary crystals will be arranged by inductive action. An X-ray examination will indicate a definite orientation of the axes of the elementary crystals.

(2) A very strong directive effect is also observed if a crystalline powder is placed under high pressure. This has also been demonstrated in the cases of wax, paraffin, and the crystalline powders succinic acid, indigo, and stearic acid—under pressures of 4000 to 5000 atmos.

(3) The phenomenon is also demonstrated in drawn metallic wires. In this case also the axial arrangement of the elementary crystals in the metal corresponds with the axis of the wire itself. A. B. W.

46. *Studies of Crystal Structure by X-Rays.* **E. C. Bain.** (Chem. and Met. Eng. 25. pp. 657–664, Oct. 5, 1921.)—The apparatus used by the author for the examination of metals and crystalline powders is described. A broad-focus molybdenum-target Coolidge tube is recommended as the source of X-rays. The specimen is supported at the centre of curvature of the recording film. Some powders, particularly graphite, tend to pack in a definite orientation. This may be prevented by stirring the powder to a paste with heavy shellac solution and drying the product. The least possible quantity of binder should be used, as the amorphous material causes random scattering of light. J. L. H.

47. *Fire-coloured Sunset and Tropical Storms.* **R. M. Dole.** (Monthly Weather Rev. 49. p. 191, April, 1921.)—The note is contributed from Wilmington, N.C. A peculiarly awe-inspiring lurid sunset (or sunrise) may be a useful indication of the approach of a tropical storm, especially when considered in relation to other signs, though it may often precede the usual warning afforded by sea-swell, unusual motion of upper clouds, etc., by 24 to 48 hours or more. The presence of cloud to reflect the light is essential for this effect, which occurs about 20 min. after sunset, and is of short duration. It is specially useful as an indication of dangerous disturbances of small diameter, which may be missed by ships, and of which no warning is accordingly received by wireless. M. A. G.

48. *Cloudburst Rainfall at Taborton, N.Y., August* 10, 1920. **R. E. Horton** and **G. T. Todd.** (Monthly Weather Rev. 49. pp. 202–204, April, 1921.)—Measurement of the water caught in a pail indicated a fall of 11·6 in. during the 24 hours, about 9 in. being concentrated in the late afternoon. An examination of the effects of the downpour on the land surface, the observed rise of water in a neighbouring pond, and some experiments on the splash from a roof near the pail, and eddies round the pail lead to the conclusion that the fall certainly amounted to 8 in. It was very local, falling off in all directions to less than 2 in. some 15 or 20 miles away. M. A. G.

49. *Cyclonic Storm of July* 1, 1920, *at Keokuk, Iowa.* **R. H. Bolster.** (Monthly Weather Rev. 49. pp. 199–200, April, 1921.)—This storm, which is not regarded as a tornado, though confined to a very small area, was notable for the rapid increase of wind from 5 miles/hr. at 9.12 p.m. to about 125 miles/hr. at 9.20 p.m. as registered by an anemometer exposed on a 60-ft. flagstaff of the Mississippi River Power Co. at Keokuk. A speed of the order of 100 miles/hr. was maintained for about 15 minutes, but by 9.55 p.m. it had decreased to 18 miles/hr., and at 10 p.m. to 11 miles/hr. 0·36 in. of rain was recorded. The direction of the wind during the storm was N. to N.W., down the river, and the intensity greatest at Keokuk, where the pond elevation at the Mississippi dam rose almost a foot. Before settling down to its previous constant level, a series of surges were noted at an interval of about 1¼ hour from crest to trough, indicating that the surges went upstream to about Montrose, where the storm originated. M. A. G.

50. *Correlation of Maximum Rain Intensities for Long and Short Time-Intervals.* **R. E. Horton.** (Monthly Weather Rev. 49. pp. 200–202, April, 1921.)—The data employed consist of 25 years' observations from recording gauges at New Orleans. Choosing any interval of time t, the max. rainfall P during any such interval in the 25 years is noted. The curve obtained by plotting P against t for values of the latter from a few minutes up to one year is shown to be closely represented by a formula $P = P_e + P_n$, where P_e is of the form: $at\exp(-t^b)$, and P_n of the form: ct^d. For values of t up to 8 hours P_n is small compared with P_e, while for larger values there is a transition to the other law, P_e becoming small compared with P_n for intervals greater than about a month.

M. A. G.

51. *Simultaneous Oscillations of Pressure and Wind at the Summit of the Eiffel Tower.* **R. Dongier.** (Comptes Rendus, 172. pp. 1304–1306, May 23, 1921.)—The author has already indicated how the Eiffel Tower records may show the passage of the "steering surface" or front of the "warm sector" of a depression and the associated oscillations of wind and temperature with sensibly constant pressure [see Abs. 1015 (1921)]. The passage of the " squall surface " in rear of the " warm sector " may be similarly indicated associated with a somewhat different phenomenon. In this case, after the arrival of the cold air, there may occur simultaneous oscillations of wind and pressure with sensibly constant temperature. Such cases, which are not frequent, however, are held to support a view expressed by J. Bjerknes, that the wedge of cold air in the rear of a depression may execute vertical oscillations while undercutting the less dense air of the " warm sector." A good case, the records of which are reproduced, occurred on Sept. 15, 1906. M. A. G.

52. *Influence of Topography and Heating of the Ground on Surface Winds.* **O. Mengel.** (Comptes Rendus, 172. pp. 1432–1434, June 6, 1921.)—Emphasises the marked effect which local conditions may exert in modifying the wind due to the pressure distribution alone. A special study has been made of the winds recorded at certain stations at the eastern extremity of the Pyrenees, and examples are quoted. For the successful application of Guilbert's rules in forecasting, especially in regard to convergent and divergent winds, it is thought that the local component should be eliminated. M. A. G.

53. *Actinometric and Polarimetric Measurements at High Levels.* **A. Boutaric.** (Comptes Rendus, 172. pp. 1519–1521, June 13, 1921.)—The author's observations at Montpellier show that the intensity of solar radiation, for a given thickness of air traversed, varies in the same sense as the polarisation of the diffuse light. To test this for a high-level station observations were made on the Pic du Midi (2859 m.) from Aug. 11 to Aug. 24, 1919. For the first few days the law was obeyed, but afterwards there were some notable exceptions, the polarisation falling too low for high intensities of solar radiation. This is attributed to the presence on those occasions of a cumuliform cloud layer, below the observatory level, which greatly increased the amount of diffuse light, thus decreasing the proportion polarised. This effect is independent of the transparency of the atmosphere. A similar diminution of polarisation has been noted by Kimball in the case of snow cover. M. A. G.

54. *Bibliographic Notes on the Temperature Charts of the United States.* **R. de C. Ward.** (Monthly Weather Rev. 49. pp. 277–280, May, 1921.)—References are given (*a*) to mean annual, seasonal, and monthly isothermal charts of the United States, the earliest dating back to 1844; (*b*) to miscellaneous temperature charts of the United States showing, for example, absolute values, range of temperature and variability of temperature; (*c*) for comparative purposes, to annual and monthly isothermal charts of the world. The references are in each case accompanied by notes, the whole forming a useful annotated bibliography. M. A. G.

55. *Psychrometric Chart for Determining the Dew-Point and Relative Humidity.* **R. B. Smith.** (Monthly Weather Rev. 49. pp. 287–293, May, 1921.)—A " collineation " nomogram based on the graphical evaluation of Ferrel's formula, $e = e' - 0{\cdot}00066B(t - t')(1 + 0{\cdot}00115t')$, where e is the actual water-vapour pressure in the air, e' the max. vapour pressure at temperature t'; t and t' are the dry- and wet-bulb temperatures respectively, and B is the barometric pressure. (Pressures in mm. of mercury and temperatures in degrees C.) M. A. G.

56. *Diffuse Radiation on Mont Blanc compared with that at Lower Levels.* **J. Vallot.** (Comptes Rendus, 172. pp. 1337–1339, May 30, 1921.)—In a previous paper observations of direct and diffuse solar radiation made at Nice have been discussed [see Abs. 1384 (1921)]. In this paper the altitude variation is considered, employing observations at Nice (50 mm.), Chamonix (1100 m.), Station du Funiculaire (2500 m.), Dôme du Goûter (4250 m.), and Mont Blanc (4350 m.). The same notation is used as before, substituting I_n for I_r, for the higher levels, to indicate reflection from snow. Considering, firstly, average values, 8 h. to 16 h., for several fine days, I_s and I_t show the known increase with altitude, the former steady, the latter steady at first and abrupt at the higher levels. I_d, however, decreases up to at least 2500 m., but increases on Mont Blanc to more than its sea-level value. This is due to the high value of I_n, which by a separate experiment was shown at times to exceed 60 % of I_s. I_e decreases with altitude and becomes zero on Mont Blanc. Selecting four particularly clear days, mid-day values of I_e equal to zero are found at Nice with corresponding values on Mont Blanc as low as $-0 \cdot 2$ cal. min.$^{-1}$, the negative sign indicating an actual balance of radiation outward from the instrument. This has the effect of making $I_{t'}$ less than I_s. M. A. G.

57. *South-West Monsoon.* **G. C. Simpson.** (Roy. Meteorolog. Soc., J. 47. pp. 151–172, July, 1921.)—The inadequacy of the idea that the south-west monsoon which blows from June to Sept. is due to an indraught of air to take the place of air which is caused to rise through intense heating over India, is shown by the fact that the mean temperature for May before the monsoon sets in is higher than for July, when the monsoon is at its height, and also by the fact that during the monsoon the hottest parts of India, particularly the N.W., are the driest. Its cause is indeed of a far more general nature, and it is necessary to consider a much greater area, when the monsoon will be seen in its true light, merely as a portion of the circulation associated with a vast low-pressure area centred N.W. of India, and extending over most of Asia and the North of Africa. The cause of this low-pressure area is primarily the difference of temperature between land and sea, but many influences, including the rotation of the earth, combine to determine its actual location and extent. The air which enters this system as the south-west monsoon is drawn from the S.E. trades, which, crossing the equator at this period, are deviated to the N.E., reaching India after traversing some 4000 miles of ocean. The air is thus very rich in water-vapour ; this alone, however, does not account for the monsoon rainfall, the distribution of which is controlled by the disposition of the high land, and which is, in fact, mainly orographic. Having now seen that the monsoon and its rainfall are not dependent on insolation over India, it becomes clear that the high temperatures of May in all parts, and of the monsoon months in the drier parts, are due to the absence of cloud and rain. In May the Asiatic low is not fully developed, and the S.E. trades do not yet feed into the Arabian Sea, with the result that the winds over India, though from the Arabian Sea, are not strong and not sufficiently humid for the general monsoon cloud and rain to set in, though thunderstorms are prevalent at this time.

The supply of air from the S.E. trades appears to be an essential part of the mechanism of the S.W. monsoon, and the failure of the monsoon, *e.g.* the disastrous break in the rains in 1899, is found to be associated with the failure of the S.E. trades to cross the equator. M. A. G.

58. *Basis for a Rational Classification of Clouds.* **P. Schereschewsky.** (Comptes Rendus, 173. pp. 96–98, July 11, 1921.)—The need for an extension of the International Cloud Classification to meet present-day practical and theoretical requirements has led the author to seek an entirely new basis for classification, instead of form and altitude alone. The fundamental conception is that of a cloud system of which the state of the sky, as viewed from a particular observing station, is merely a part which is in turn composed of individual clouds. The basis having been found, a rational nomenclature would be one expressing concisely as many properties of the cloud as possible. Thus, borrowing an idea from chemistry, a cloud might be described by three letters, the first indicating the type of system to which it belongs, the second the sector of the system, and the third the morphological characteristics and height. M. A. G.

59. *Altitudes of the Bases of Lower Clouds.* **O. L. Lewis.** (Monthly Weather Rev. 49. pp. 342–347, June, 1921.)—The results in this paper are based on 5500 determinations of the height of cloud bases at United States Weather Bureau stations by means of kites or pilot-balloons. They are presented in the form of diagrams showing the frequency of cloud bases at different altitudes. One of the chief conclusions drawn is that there is no appreciable variation either with latitude or season, in the height of max. frequency of each type of lower cloud. Grouping stratus and alto-stratus together, a single maximum is found in the neighbourhood of 400 m.; above this the decrease is rapid at first, and then slower to zero near 7 km. There is no evidence of a marked secondary maximum at any level, so that stratus appears to merge continuously into alto-stratus. The diagram for cumulus and cumulo-nimbus also shows a single maximum, but between 1000 and 1700 m., with a gradual decrease each side. Strato-cumulus and alto-cumulus, together, show a maximum between 750 and 1000 m., and again there is no secondary maximum, the two types having no sharp demarcation. Combining all observations there is a single maximum at the stratus level, 400 m., with a continuous decrease above which appears at first to controvert the often expressed idea that there are several regions of max. condensation; but the evidence is not by any means conclusive. M. A. G.

60. *New Method of Forecasting Barometric Changes.* **E. Delcambre** and **P. Schereschewsky.** (Comptes Rendus, 172. pp. 1673–1676, June 27, 1921.)—The method consists of anticipating the movement and development of "noyaux des variations barométriques," or isallobaric systems. These have been previously described [see Abs. 1014 (1921)]. Their evolution may take place in various ways: (1) by a motion of translation, which may be uniform and is, in general, more regular than that of depressions, (2) by translation accompanied by change in intensity, (3) by translation accompanied by decomposition into two elements, often moving off in directions at right angles, (4) by change of intensity without translation. Such systems, as a general rule, obey a law by which they move in such a way as to leave anticyclones on the right. The method of evolution in a particular case is recognised by studying the "noyaux" for 12 h. in relation to those for 3 h., while the velocity of translation is determined by studying successive charts drawn at intervals of 6 hours. These changes, once determined, enable the barometric variations of the ensuing 12 hours, and sometimes 24 hours, to be forecast. While the notion of an isallobaric chart is not new, the present method of employment is claimed to be distinct, and in particular the charts demand, for their construction, a network of stations two or three times as close as any previously used for such a purpose.

M. A. G.

61. *Mean Values in Meteorology.* **J. Mascart.** (Comptes Rendus, 173. pp. 94–96, July 11, 1921.)—The average value, over a series of years, of the mean temperature of a particular day of the year, is termed the "normal mean" for that day. The same term applies to any other meteorological element. It is pointed out that the formation of true "normal means" presents certain difficulties. A curve of daily "normal means" formed for given dates is not smooth, but presents singularities, some dates or groups of dates appearing specially favoured. It is a matter for investigation to determine how far, if at all, these are real. The author finds that they arise, at least partly, through forming the "normal mean" for a given date instead of choosing that day in each year on which the earth traverses, as nearly as possible, the same portion of its orbit, which may occur on one of three consecutive dates according to the year. Utilising 40 years' observations, and forming, on these lines, as a simple illustration, the frequency of occurrence of frost on each day of the year, a much nearer approach to a smooth curve is obtained than by adhering to the same "date" in each year. Normal means utilised in theoretical investigations should be formed on the suggested plan.

M. A. G.

62. *Seasonal Forecasting of Precipitation—Pacific Coast.* **A. J. Henry.** (Monthly Weather Rev. 49. pp. 213–219, April, 1921.)—An examination of the available data shows that, as a general rule, the departure of seasonal precipitation from normal is not of the same magnitude, nor, indeed, necessarily of the same sign, throughout the Pacific States. A particular study is made of the winter rainfall (Dec. to Feb.), and three types of wet winter are recognised: (1) those which give heavy rains in all three States, (2) those in which rain is in excess in California and deficient in Washington and Oregon, (3) the reverse of (2). Dry winters lend themselves to similar classification. Each kind is studied in relation to pressure distribution, and to the so-called "centres of action," the Aleutian Low and the Pacific High. The author is led to state that a knowledge of the pressure distribution over the north-eastern portion of the Pacific and the Canadian North-West affords the most hopeful avenue of approach to a rational solution of the problem indicated in the title. A long series of observations from the Pacific is needed, and the problem must be studied in relation to the general atmospheric circulation.

M. A. G.

63. *Earthquake-Wave Analysis.* **O. Klotz.** (Roy. Soc. Canada, Trans. 14. Ser. 3. Sect. 3. pp. 47–53, 1921.)—The results of a first attempt to apply the Henrici harmonic analyser and a 32-element harmonic synthesiser [see Abs. 267 and 1182 (1916)] are given. The analysis is limited to the extent that periods of waves which are not sub-multiples of the assumed period of the compound curve are excluded from the analysis, even though they exist. For a satisfactory study of seismograms the instruments should be available for instant use, so that consideration may be given to the assumption of different compound curves as the periodic one, in order that the really predominant waves may emerge; and comparison made of the analysis of different seismograms for the discovery of selective waves, dependent on the nature of the material of the paths and their depths. W. A. R.

64. *Age of the Earth.* **Rayleigh, W. J. Sollas, J. W. Gregory,** and **H. Jeffreys.** (Nature, 108. pp. 279–284, Oct. 27, 1921. Discussion at Meeting of the British Assoc., Edinburgh, Sept., 1921. Chem. News, 123. pp. 185–186, Oct. 7, 1921.)—**Rayleigh** summed up Kelvin's argument, and then pointed out that it was practically certain that radioactive materials are generating as much heat as is radiated out into space. Radio-active methods of research from the lead ratios indicate a moderate multiple of 1000 million years as the age of the earth's crust under conditions suitable for the habitation of living beings, and no other considerations from the side of pure physics or astronomy afford any definite presumption against the estimate. The helium ratios give values about one-third of those derived from the lead.

W. J. Sollas pointed out that if uranium once transformed itself at a greater rate than at present the estimate given above would be too long, and referred to Joly's evidence that the two inner rings of pleochroic haloes in mica are larger than their calculated values by one-sixth, indicating that in Caledonian times a metope of uranium may have existed with properties different from those of existing uranium. On the geological side the exact determinations of rate of sedimentary deposition made by de Geer shorten previous estimates of the post-glacial time to 12,000 years.

J. W. Gregory indicated the errors that have affected the estimation of the earth's age from considerations of oceanic salinity, and gave as his opinion that these estimates on account of these errors should be increased fivefold; and that even a greater increase necessary to bring the geological estimates into agreement with the physical is not inconsistent with geological evidence.

H. Jeffreys considered that the known facts with regard to the earth's thermal condition could be reconciled if the age of the earth were taken to be at least $1 \cdot 6 \times 10^9$ years. He also gave another estimate based on the tidal ("planetesimal" theory of Chamberlin and Moulton) theory of the origin of the solar system, and showed that the time required agreed with the estimates of the uranium-lead ratios. W. A. R.

65. *Curiosities of the Earth's Field of Gravity.* **W. D. Lambert.** (Am. J. Sci. 2. pp. 129–158, Sept., 1921.)—The ocean surface is not spherical, but is spheroidal on account of the earth's rotation. A "level" surface is one which conforms to this spheroid of revolution. The curiosities referred to are:—(1) The level surface marking the outer limit of the atmosphere has not a continuous curvature at the equator, but a sharp ridge, which is the intersection of two nappes of the surface at 120°.

(2) A smooth lake has different elevations at its ends, the N. end of Lake Michigan being 8 cm. nearer sea-level than the S. end. (3) Large bodies have a tendency to "fall" towards the equator. (4) A rod suspended like the horizontal beam of an Eätvös balance tends to "fall" by twisting about the supporting fibre. (5) Great local irregularities occur in the curvature of the "level" surface. P. E. S.

66. *Depth of Earthquake Focus.* **S. Nakamura.** (Phys. Math. Soc. Japan, Proc. 3. pp. 116–120, Oct., 1921.)—A method is given for calculating the depth of focus, or the epicentral distance, of an earthquake from the time of duration of the preliminary tremors. The results in some actual cases are tabulated; and it may be noted that the depths obtained in this way vary from 10 to over 100 km. for the same earthquake at different stations; the depths for different earthquakes at the same station, however, only vary within a few km.—the maximum given being about 20 km. W. A. R.

67. *Mass of the Atmosphere and of each of its More Important Constituents.* **W. J. Humphreys.** (Monthly Weather Rev. 49. p. 341, June, 1921.)—The total mass of the atmosphere, computed from the average pressure at the earth's surface, is approximately $5 \cdot 11 \times 10^{18}$ kg., while the average mass of water-vapour present is $1 \cdot 33 \times 10^{16}$ kg. In estimating the amounts of each constituent it is assumed that, apart from water-vapour, the percentage composition is constant throughout the troposphere, and that diffusive separation of the gases in the upper atmosphere commences at the base of the stratosphere. Ramsay's figures are adopted for the composition at the surface, and lead to the following results, only the first two significant figures being quoted:—N, $3 \cdot 9 \times 10^{18}$; O, $1 \cdot 2 \times 10^{18}$; A, $6 \cdot 2 \times 10^{16}$; H_2O, $1 \cdot 3 \times 10^{16}$; CO_2, $2 \cdot 2 \times 10^{15}$; H, $1 \cdot 3 \times 10^{14}$; Ne, $4 \cdot 7 \times 10^{13}$; Kr, $6 \cdot 4 \times 10^{12}$; He, $6 \cdot 3 \times 10^{12}$; Xe, $1 \cdot 2 \times 10^{12}$ kilogrammes. M. A. G.

68. *Must it be assumed that the Earth's Core has a High Temperature?* **C. Lönnquist.** (Ark. f. Mat., Astron. och Fysik, Stockholm. 14. [No. 26. pp. 1–26] 1920.)—After briefly reviewing the work of previous investigators, the author enunciates his thesis. As our earth may have originated from an extinct sun of planetary dimensions penetrating into a nebula, is it not possible that its interior may be cold in spite of the hot layer beneath the surface? Calculations based on Fourier's equation for the conduction of heat show that the period required for raising the temperature of the earth's interior must be reckoned at thousands of millions of years. The occurrence in cosmic space of completely cooled bodies of large dimensions is not common, but for a body of the earth's dimensions not unthinkable. The thesis is therefore: Our earth may have been a mass, cooled throughout, penetrating into a nebula, in which case its central portions remain at a low temperature. It appears from seismological calculations that the velocity of earthquake waves decreases towards the centre. This points to the core being of high density. The solar system may be imagined as passing through regions of higher or lower temperature, or, more correctly, through empty space or space filled with nebulous matter. The hot layer under the earth's crust is an accumulation of the heat derived from the last nebula traversed. Then follows, based on Fourier's equation, a mathematical discussion of the possible distribution of heat in a sphere. First the problem, originally handled by Kelvin, of a sphere of uniform initial temperature placed in a cool medium. Then the problem of a cool sphere placed in a warm medium, so that the temperature rises by conduction inwards. Then the case of a sphere having a cool interior and warm surface layer placed in a medium of the same temperature as the surface layer. Finally, that of a cool sphere with a warm surface layer placed in a cool medium, in which case the surface layer loses heat by radiation and by conduction to the cool interior.

In considering how far one or other of these calculations may be applied to the hypothetical prehistory of the earth, the author imagines the existence of three phases. I. Nebulous matter accumulates on the surface in a liquid or gaseous state. The atmosphere thus formed grows by continued accumulation. The liberated heat causes radiation, thus tending to keep the temperature constant. II. The accumulation is nearly completed. Radiation causes the temperature of the gaseous envelope to fall, thus leading to condensation of the atmosphere. III. The molten stratum is cooled by radiation and becomes solid; its temperature falls rapidly, and soon becomes constant owing to equilibrium between radiation and absorption. Heat is subsequently conducted from the molten stratum outwardly to the cooled surface, and inwardly to the iron core. We are still in this phase. The hypothesis of the existence of a cold iron core appears to the author to be an admissible inference from these investigations, and as a final deduction he ventures to assert that it is not impossible, nor even improbable, that the earth's core is solid and of a low temperature. E. F.

69. *Sun's Rotation Law Explained by Evolution and Oblateness of Proto-Sun.* **E. Belot.** (Comptes Rendus, 173. pp. 27–30, July 4, 1921.)—The proto-sun had an equatorial radius of 0·29 astronomical units; so extending nearly as far as Mercury's present orbit. Its period of rotation was 57 days, and its oblateness considerable. The above forms the author's starting-point. He assumes the proto-sun to have been a Class M Cepheid, and considers the probable course of evolution on the alternative hypotheses of homogeneity and of density varying inversely as the square of the radius. He finds the oblate proto-sun will have reduced to a sphere, and caused a variation of speed of rotation with latitude.

Thus the law of rotation of the sun is the result of spherical condensation according to the law of areas, of an ellipsoid of ellipticity 0·377 rotating uniformly, and having at latitude 30° a common parallel with a sphere of the same volume. By another method he has inferred 0·384 for the oblateness. He shows in a diagram the effect of this deformation, indicating his view of the evolution M, K, G, F in ascending type, and deducing from the limiting latitude 35°·16′, to which the common parallel conforms, an explanation of the confinement of sun-spots to zones of lower latitude. W. W. B.

70. *Mutual Influence of Fraunhofer Lines.* **W. H. Julius.** (Astrophys. J. 54. pp. 92–115, Sept., 1921.)—*Dispersion Theory of Fraunhofer Lines.*—This theory, which assumes that the lines are almost entirely the effect of anomalous refraction and scattering, was developed by the author some years ago and led to the prediction and discovery of the mutual influence of neighbouring Fraunhofer lines, for which conclusive *evidence* is presented in the paper. The existence of this effect, not otherwise explained as yet, is considered by the author powerfully to support this theory. He concludes that anomalous dispersion is a most effective, perhaps the only, cause of the entire *limb-centre shifts*, and must therefore also produce *centre-arc shifts*. If so the *gravitational shift* required by the general relativity theory may not exist.

Mutual Influence of Neighbouring Fraunhofer Lines.—Of the 866 lines for which the limb-centre shifts were measured at Mt. Wilson in 1910, or at Kodaikanal Observatory in 1914–16, 128 have close companions which may be expected on theoretical grounds to influence their position. A study of the observations shows that there is, without doubt, a mutual influence equal, on the average, to 2/5 of the normal limb-centre shift, a companion on the violet side causing an increase, a companion on the red side a decrease, of the shift. AUTHOR.

71. *Photographs of Venus.* **F. Quénisset.** (Comptes Rendus, 172. pp. 1645–1647, June 27, 1921.)—Repeating an earlier success [see Abs. 286 (1912)], the author has obtained with the Paris Observatory telescope (0·16 m. aperture and 2·9 m. focal length) a series of photographs of the planet Venus. On each plate several images were exposed, in order to avoid defects in the plates and accidental markings. A sketch is given of the most successful photograph, obtained on Feb. 23, 1921, when, with the 0·24-m. equatorial, a marking was plainly seen visually. The drawing given is by Antoniadi. The best results were obtained with Eastman lantern plates, being slow and with good contrast. Seventeen exposures, varying from 2 to 10 secs., were made on this plate in ten minutes. The diameter of the image of Venus was 3·3 mm. The special features seen on all but two of the plates (2 secs. being found insufficient) were two dark spots, one extending inwards from the centre of the terminator, the other to the south of it with an intervening bright patch, possibly due to contrast. The author is uncertain whether to regard them as denser portions of atmosphere, or as dark surface showing through. Next day these two spots were not found. He wishes to urge the importance of systematic photography of the planet with good atmospheric and instrumental conditions. W. W. B.

72. *Deviation of Light due to Gravitation.* **J. Soldner, 1801.** *Introduction by P. Lenard.* (Ann. d. Physik, 65. 7. pp. 593–604, Sept. 27, 1921.)—120 years ago Soldner calculated that a star viewed close to the sun's disc would be apparently displaced by 0″·85. This displacement is in approximate agreement with the observations hitherto made during solar eclipses. Soldner's preliminary assumption was that light, coming from matter at a high temperature, is also a material thing, and consequently is subject to gravitation. The formula obtained by Soldner for the total deviation is the same as that found by Einstein in 1911 from the relativity theory, while according to the generalised theory the deviation has double the value. [See Abs. 596 (1921).] A. W.

73. *Special Case of Diffraction of Circular Celestial Images.* **M. Hamy.** (Bull Astronomique, 1. No. 4. pp. 197–212, 1921.)—In the endeavour to exclude the effect of diffraction in measuring such a quantity as the solar diameter the author has previously experimented with a very narrow slit. [See Abs. 1254 (1920).] If the angular radius of the sun $= \epsilon$, the length of the slit $= h$, and its width $= a$, using a monochromatic screen corresponding to a wave length λ, he uses a parameter n^2/m, where $m = \pi h \sin \epsilon/\lambda$ and $n = \pi a \sin \epsilon/\lambda$, and finds that $n^2 m = \frac{1}{2}$ is a reasonable value for his purpose. He tabulates his coordinates with this assumed value with certain transformations, and then considers the variation of intensity towards the limb; since his general formulæ apply only to a disc of absolutely uniform brightness. He concludes that a better image of the limb is obtained with a narrow slit of length equal to the diameter of the objective, and claims the additional advantage of avoiding most of the heating effect.

He intends to discover the amount of the diffraction, by which the geometrical limb of the sun differs from its optical limb, but for the present is satisfied that the proposed slit enables him to eliminate the effect to a great extent. He proposes placing the slit at right angles to the meridian for observations of the R.A. limbs of the sun and in the meridian for the Z.D. limbs, pointing out, however, that the collimation of the instrument must be checked for each of these positions of the slit, compared with full aperture. The ordinary method of reducing the intensity by using a smaller circular aperture is, he considers, much less satisfactory, as it alters practically the figure of the lens and does not sufficiently reduce the heating effect. W. W. B.

74. *Avoidance of Atmospheric Dispersion in Measures with the Stellar Interferometer.* **G. Van Biesbroeck.** (Astrophys, J. 54. pp. 78–80, July, 1921.)—The author uses a direct-vision prism with the stellar interferometer in order to avoid the disturbing effects of atmospheric dispersion. L. H. W.

75. *Relativity Shift in Solar Spectrum.* **J. Evershed.** (Observatory, 44. pp. 243–245, Aug., 1921.)—The result of the author's investigation on this subject [see Abs. 793 (1921)] has met with criticism on various grounds, and he is now defending it against strictures based on St. John's work at Mt. Wilson, which gave a different result. He claims that an increase in the scale of photographs beyond 2 mm. per Å. unit gains practically nothing, and even asserts that his smaller image of the sun is rather an advantage than otherwise, in minimising irregular line-shifts. He considers that his positive-on-negative method of measurement gives him the advantage of practically doubling the dispersion without loss of distinctness, and also enables the detection of want of symmetry in a line which might otherwise vitiate measures.

The *primâ facie* evidence appears to him favourable to the Einstein shift, but there are many anomalies to be explained, especially in relation to Cy band-lines. He thinks, however, that the Einstein effect is superposed on some motion shift with a maximum at the centre, and is also quite prepared to sacrifice all the negative evidence of his Venus observations, a series of which he hopes to repeat before the end of the year. W. W. B.

76. *Ultra-Violet End of Solar Spectrum.* **C. Fabry** and **H. Buisson.** (J. de Physique et le Radium, 2. pp. 197–226, July, 1921.)—The authors describe a new rational form of double spectroscope for the study of the extreme ultra-violet rays: it eliminates any overlapping with the more intense radiation, and so allows a clear unblurred photograph to be taken of the extreme rays. Absorbing screens suitably placed in one part of the spectrum, enable them, by equalising the intensity, to obtain on the same plate measurable images of the whole region under investigation (3150 Å. to 2920 Å.). They thus, determining the intensity from the photograph, are enabled to study quantitatively the atmospheric absorption, and to prove that its law as a function of the wave-length is the same as that of ozone, confirming the theory that it is the ozone that is responsible for the absorption. The thickness of ozone traversed by vertical rays, considered as gas under atmospheric pressure, averages about 3 mm., but varies considerably from day to day. This ozone layer is at a great height, for which they give a reasonable explanation. As regards the intensity of the solar radiation outside the atmosphere, they find no sudden diminution of intensity in any part of the spectrum they can reach. So they think there is no reason to suppose that the atmospheric absorption limits the spectrum in any way, a conclusion confirmed by a comparison of the sun's limb with its centre.

In regard to the variation of ozone from day to day, they require continuous study of this matter, all over the world, wherever suitably equipped observatories can be persuaded to undertake it. W. W. B.

77. *Seasonal Changes in Lunar Craters.* **W. H. Pickering.** (Roy. Astron. Soc., M.N. 81. pp. 490–495, June, 1921.)—The craters considered are Conon, Aristillus, and Eratosthenes, near the centre of the moon's disc, and so not liable to librational change. Bright and dark markings show changes of size, shape, and position. Features claimed for Conon are a seasonal bright patch of snow, a small crater that becomes a mound, and a cloud or fog on the crater floor. In Aristillus a network of fine lines is said to appear, invisible at sunrise or sunset and most marked when the sun is vertical over them. They cannot therefore be cracks. They broaden at noon or midsummer (convertible terms on the moon). When near the terminator Eratosthenes and Copernicus are so much alike that one may be mistaken for the other. At full moon, Copernicus is white, and Eratosthenes dark, so the author claims snow for one and some sort of vegetation for the other. Several other conspicuous markings in Eratosthenes show considerable variation, one of them in the few hours of a single night's observation. Two of these "runs" show motion on the disc, the max. speed being 132 feet per hour. The author considers this a proof that life exists in some form on the moon as well as on Mars, whose "canals" show similar shifts. More attention is asked for this field of investigation, as the author considers all explanations very improbable, though that of vegetation appears to him rather less improbable than others. W. W. B.

78. *Bright Object Near the Sun.* (English Mechanic, Aug. 19, 1921. Astron. Nachr. No. 5116. Nature, 108. p. 69, Sept. 8, 1921.—Abstract.) —The object was observed in England on Aug. 7, some hours before the Mount Hamilton observation, at Ferndown, Dorset, about 7h. G.M.T. magnitude – 2, 4° distant from sun, and at Wolverhampton with binoculars shortly after sunset, noted as reddish, elongated towards the sun, at 6° distance. The luminous bands seen at Königstuhl and

Sonneberg observatories on August 8 at 12h. G.M.T. were probably auroral. (Astron. Nachr. No. 5118. Nature, 108. p. 98, Sept. 15, 1921. —Abstract.)—The object was observed at Plauen, Vogtland, by several people. It appeared like Venus at its greatest brilliancy. From accurate observations of its position at G.M.T. 7h. 35m., M. Wolf deduced its R.A. 11h. 6·7m. and N. Decl. 7° 9′. Jupiter was not very far from this position, but could not have been visible. At G.M.T. 15h. the Lick Observatory position was about R.A. 9h. 22m. and N. Decl. 15° 8′. It does not seem probable that even a comet could satisfy all the observations. W. W. B.

79. *Standard Time for Solar Observations.* **C. P. Butler.** (Observatory, 44. p. 226, July, 1921.)—The writer draws attention to some recent publications in which solar physics observations have been given in astronomical time, not in accordance with the established practice at Greenwich, which he recommends for universal use, deprecating the uncertainty likely to be introduced by varying the practice by which all solar observations are recorded in Greenwich Civil Time called G.M.T. (Civil). W. W. B.

80. *Systematic Displacements of Lines in Spectra of Venus.* **C. E. St. John** and **S. B. Nicholson.** (Mt. Wilson Observat. Contrib. No. 208. Astrophys. J. 53. pp. 380–391, June, 1921.)—Under certain conditions of observation there are line displacements to the violet of a few thousandths of an ångstrom when comparison is made with the position of the lines in the spectrum of integrated skylight. Other conditions remaining constant, the displacements are greater at low than at high altitudes.

Atmospheric Refraction.—The correlation with the altitude at the time of observation points to refraction as the controlling factor rather than to a repulsive "earth-effect" acting on the solar vapours as suggested by Evershed. The altitude correlation is represented by $\Delta\lambda 10^{-3} = 1{\cdot}4 - 1{\cdot}0 \cot h$. The residuals, after removing the effect depending upon altitude, correlate equally well with the semi-diameter D of Venus, the phase angle i, or the angle VSE. The observations are satisfactorily represented by the relation $\Delta\lambda 10^{-3} = 1{\cdot}3 - (8{\cdot}5 \cot h)/D$ which is deduced from the assumption that the observed displacements are caused by unsymmetrical illumination of the slit due to the separation of the visual and photographic images by atmospheric refraction, and that the unequal illumination is a function of the diameter of the image and the width of the slit.

Superposed Skylight.—Spectroscopic observations of Venus beginning at sunset or ending at sunrise are not measurably affected by superposed skylight. AUTHORS.

81. *Solar Eclipse Results and Relativity.* **C. E. Stromeyer.** (Nature, 107. p. 682, July 28, 1921.)—Examining Eddington's Principé results, not to attempt to confirm any theory, but to discover an empirical relation, the author is impressed with the effect of the astigmatism of the cœlostat. He obtains some uncomfortably large values for corrections and appears to question the validity of some of Eddington's corrections. He sums up dead against the employment of a cœlostat for such a purpose.

F. W. Dyson (in a following note) says the astigmatism effect has been much exaggerated, giving figures in support of his contention and referring to a complete discussion by H. N. Russell. [See Abs. 618 (1921).] W. W. B.

82. *Photographic Photometry of the Moon's Surface; Values of Average Albedo.* **F. W. P. Götz.** (Osterberg Observat. Tübingen, Publ. 1. No. 2. 1919. Zeits. Instrumentenk. 40. pp. 183–184, Sept., 1920.—Abstract.) —The author's results of an investigation completed in 1915 are now published, the brightness relations and albedo of 55 selected places on the moon's surface at about full moon having been studied.

Owing to the great diversity of the linear surface features as regards shape, colour, and brightness, a value for the average albedo of the moon is unreliable; the albedo of single places on the surface can, however, be definitely determined by means of the law of illumination. Such observations have hitherto been lacking.

The author's series of nearly uniformly distributed points on the surface are as to 20 of them identical with those used by W. F. Wislicenus. The difficulty of the necessary time interval between observations if comparisons are made between the sun's brightness and that of the moon, is obviated by making use of the image of Polaris, photographed on the same plate with that of the moon. The photographic brightness difference between the sun and Polaris was taken as 28·69 magnitudes by Birck (1919).

The plates were taken by means of the observatory's refractor, which has an apochromatic object glass of 130-mm. aperature, 2400-mm. focal length; a magnifying system giving a lunar image of 55 mm. was used and an exposure of 1 sec. ± 1 %. For the stellar image the exposure was 60 secs., and the magnifying system omitted: the image was 1·8 mm. in diameter. Eastman super-sensitive plates were employed and images of Polaris obtained on either side of the moon's image.

The images were then compared for "blackening" by viewing them by means of a metal filament lamp, a neutral-tint wedge being interposed, of which the absorption was four magnitudes over a length of 75 mm. The blackening measurements were made by means of a Hartmann microphotometer provided with a coordinate-measuring device. An investigation of the loss of light entailed by the use of the enlarging system is described: this showed a loss of 0·61 to 0·69 magnitude according to the amount of stopping down of the object glass.

The final result obtained is that the albedo of the 55 places examined ranges between 0·312 and 0·109. The values given by Müller for the albedo of the whole lunar surface is 0·172, and by Pickering 0·181.
L. H. W.

83. *Distances of Globular Clusters.* **H. Shapley** and **H. D. Curtis.** (National Research Council, Bull., Washington, May, 1921. Nature, 107. p. 825, Aug. 25, 1921.—Abstract.)—The authors support conflicting views in a discussion on this subject. In the case of the Hercules cluster, Shapley argues from the presence of B stars, of absolute magnitude zero or brighter, that the distance of the cluster is 36,000 light-years. Curtis, preferring to base his calculations on all stars instead of B-stars, obtains a distance of 3600 light-years. Shapley replies to this that since faint stars become invisible at a distance the average must be a function of distance. *Cepheid variables.*—Shapley, moreover, has obtained a marked correlation between period and absolute magnitude in the case of Cepheid variables. Curtis, using a larger number of galactic Cepheids, shows that the correlation is much less marked. Shapley replies that his Cepheid method is only one of several, all giving accordant results, and that his correlation depends more upon this accordance than on any one of the methods. *Spiral nebulæ.*—If Shapley's estimate of distances is correct, spirals, if similar to our galaxy, must be so remote that we could not expect to see novæ in them. Those that have nevertheless been found there, he considers, must be formed of diffused matter and not stellar in character. If Curtis is right about the distance this difficulty does not arise, and the spirals may quite plausibly be regarded as external galaxies. He estimates the distance of the Andromeda nebula as half a million light-years, and accounts for the peculiar distribution of spirals in relation to the galactic plane by the hypothesis of a zone of occulting matter. W. W. B.

84. *Height of Aurora.* **C. Störmer.** (Geofysiske Publ., Kristiania, 2. No. 2. Nature, 107. p. 663, July 21, 1921.—Abstract.)—Simultaneous photographs of the brilliant aurora of March 22–23, 1921, were taken at Christiania and Königsberg, 65·7 km. apart, the exposures being timed by telephone after the cameras were pointed to the same stars in Cassiopeia. The streamers had well-defined edges, and the heights of the ends of long rays were determined as 597, 550, 607, 562, 528, 485, and 519 km. respectively. The bases may be as low as 85 to 90 km., but the great heights of the edges are taken to indicate that the atmosphere must extend beyond 500 km. **C. Chree.** (Ibid. 109. pp. 47–49, Jan. 12, 1922.) W. W. B.

85. *The Spiral Nebulæ.* **A. C. Gifford.** (New Zealand J. of Sci. 4. pp. 135–139, June, 1921.)—Eddington considers that in the spiral nebulæ matter is moving either inwards or outwards along the branches of the spiral, and that the line from which the branches start out is a favoured direction for rectilinear motion. The author traverses the assumptions, the first of which, he says, involves an inverse cube law, and maintains that motion in every case is practically at right angles to the direction of the apparent spiral. He attributes the spiral form to the motion about the centre being uniform in linear, not in angular, velocity, so that the more distant portions lag further and further behind. He gives diagrams showing various stages in his idea of the evolution. He does not consider it possible for a nebula to be visible until after an encounter between systems, which meet and interpenetrate. The process takes possibly hundreds or thousands of millions of years, so he does not expect to see a new nebula appear as the result of such an encounter as is the case with novæ, which perhaps take less than an hour for their outburst. W. W. B.

86. *Statistics of Proper Motions.* **J. C. Kapteyn** and **P. J. van Rhijn.** (Astron. Lab. Groningen, Publ. No. 30. Nature, 107. p. 694, July 28, 1921.—Abstract.)—The authors give a resumé of recent catalogues and lists of proper motions, including Innes' work with the blink microscope, the effectiveness of any list being weighted according to the limiting magnitude, indicated by the number of stars. The distribution is shown to be independent of galactic latitude. In the whole sky there are 347 stars of 6th magnitude with annual proper motion greater than 0″·2, 178 greater than 0″·3, 77 greater than 0″·5, 20 greater than 1″·0, and 5 greater than 2″. The authors give this in greater detail, and also similar statistical information down to fourteenth magnitude, at which no proper motion is so great as 1″·00, but the faint-star determinations are admittedly rough. W. W. B.

87. *Place of Nebulæ in Stellar Evolution.* **H. Macpherson.** (Observatory, 44. pp. 219–225, July, 1921.)—Older theories of stellar evolution regarded the diffuse nebulæ as the "raw material" from which suns were condensed, but Russell's theory has within the last few years gained almost universal acceptance. The author, admitting this, asserts that the question of the place of the nebulæ in the evolution must be reopened. He goes into the history of the point and mentions several authorities who had already cast doubts on the old theory of the nebulæ, and suggested that instead of just raw material the nebular stuff may be the effect of disintegration. He gives about a score of quotations from various authorities dealing with different suggestions, including the case of the planetary nebulæ, the antipathy between nebulæ and red stars, the similarity between nebular envelopes and the solar corona on a very large scale, or the Zodiacal light, the apparent development of novæ through a nebular stage to that of a Wolf-Rayet star, and finally the various problems associated with spiral nebulæ. He considers that different classes of nebulæ occupy very different positions in the order of evolution, pointing to the "white" nebulæ as being probably the oldest. W. W. B.

88. *Parallax of Nova Aquilæ III.* **C. P. Olivier** and **H. L. Alden.** (Astron. J. 33. pp. 169–170, Aug. 2, 1921.) [See also Abs. 64 (1920).]—Twenty-nine plates, taken in six epochs, extending over more than two years, have been employed. Five plates taken on the day of discovery and the following day were discarded, on account of the great brightness of the novæ and the ineffectiveness at that time of the rotating sector used for diminishing the light. The resulting parallax is unfortunately negative, but this may be due to the fact that during the last four epochs the nova showed a growing disc. Other results are given for the sake of comparison and from the whole a distance of 650 light-years is deduced. W. W. B.

89. *Double-Star Measures.* **J. Mascart.** (Bull. Astronomique, 1. No. 3. pp. 131–146, 1921.)—Considering the question of the accuracy of micrometrical observations with an equatorial, the author quotes H. Struve's observations of the angular distances between Saturn's satellites, with the probable errors of these and of Eros observations at Königsberg. He compares the computed probable errors of the double-star measures of the three Struve's: Wilhelm with the Dorpat 9-in., Otto with the 15-in., and Herman with the 30-in., both at Pulkowa. He refers to Otto Struve's elaborate experiments to determine his own systematic errors, depending on differences of magnitude, the position of the eye, etc., and brings arguments in favour of the use of the reversion-prism eyepiece. He notes the special difficulties attending measures of very small angles in the several kinds of observations concerned: double stars, planetary discs and surface markings, and artificial test objects. Bigourdan's device which substitutes sharp points for wires of appreciable thickness, he thinks diminishes some of these difficulties. He gives reasons for rejecting the assumption that increasing the number of pointings will sufficiently reduce the probable error, giving specific examples of the way in which this is liable to fail. The importance of accuracy is greater in the case of such stars as ζ Cancri and 70 Ophiuchi, whose motion is irregular, owing presumably to the pressure of invisible companions, and on these he thinks it well to concentrate attention. Personal equation so-called is, he considers, too variable to lend itself to systematic correction after the manner of Otto Struve.

He mentions a set of measures of fairly wide double stars (1″ to 6″), made at Berlin by H. Struve and Guthnick, so arranged that the line joining the stars was either parallel or perpendicular to that joining the eyes. This, with the bright star alternately E. and W. or N. and S. of the fainter, gives four sets of measures. In three of the four cases Struve's corrections were predominantly positive, in the fourth case all negative.

He gives a resumé of Aitken's endeavours to secure a satisfactory uniformity in the definition of a double star, after consultation with the leading double-star observers, and concludes with his own observations made during the summer of 1911, of nine double stars, including the well-known γ Leonis, γ Virginis, ξ Scorpii, and 70 Ophiuchi.

W. W. B.

90. *Stationary H- and K-lines of Ca in Stellar Atmospheres.* **M. N. Saha.** (Nature, 107. pp. 488–489, June 16, 1921.)—The author is dealing with the difficulty experienced in answering the question why Ca only should show stationary lines, so that on the envelope hypothesis Ca vapour only should be found surrounding stars. He has already considered the sun [see Abs. 218 (1921)], and holds to his theory of "selective" radiation-pressure acting on ionised Ca atoms, and now discusses the difference to be expected in the case of stars with much higher surface temperatures. He divides the other light elements into two groups: (1) non-metals, such as H, He, N, O, Ne, and A, with high ionisation potential, whose resonance-lines are in the extreme ultra-violet, and (2) elements such as Na, K, Mg, Al, Sc, Ti, Fe, which have ionisation potentials of 5 to 8 volts, and so are probably mostly ionised. Not one of these, however, is known to have resonance-lines between λ3000 and λ6000, and so Ca only remains with a resonance-line in the front of the spectrum, to which observation is practically limited. He hopes that the difficulty of atmospheric absorption may some day be surmounted, and that ionised Na, K, etc., will then be found in the space round B- and A-stars, especially B-stars which show stationary H- and K-lines.

W. W. B.

91. *Diameter of Arcturus.* **F. G. Pease.** (Astron. Soc. Pacific, Publ. June, 1921. Nature, 107. p. 725, Aug. 4, 1921.—Abstract.)—After the successful measurement of Betelgeuse with the interferometer on the 100-in. Hooker telescope at Mount Wilson, attention was directed to other stars. Arcturus on some nights of poor seeing showed indication of fringe diminution with increasing distance between mirrors. On April 15, with good definition, the fringes disappeared with separation of 19·5 ft. As the maximum separation of the present apparatus is only 20 ft. the next maximum of fringes could not be tested, but the 19·5 ft. is considered to be within 0·5 ft. of the truth. The deduced angular diameter is 0″·0237, near the mean of the estimations of Eddington, Russell, and Hertzsprung. Assuming the parallax to be 0°·116, the mean of best recent measures, the linear diameter comes out at 19,000,000 miles, or 22 times that of the sun.

Aldebaran is suspected to have a rather greater angular diameter but the nights of observation were of very poor definition. Probably a longer beam than 20 ft. will be required to measure Pollux and α Tauri. The introduction of a motor to move both mirrors by screws, to replace the present method of doing so by hand, will greatly facilitate future measures. W. W. B.

92. *Star-Discs.* **A. Buxton.** (Roy. Astron. Soc., M.N. 81. pp. 547–565, June, 1921.)—The author's intention is to extend the data used by Conrady [Abs. 1376 (1919)] and to confirm previous conclusions. He deals with the intensity of the Airy spurious disc; with the amplitudes and intensities under out-of-focus conditions; with the intensities when spherical aberration is present. He computes the conditions under which spherical aberration can be made to balance out-of-focus, giving diagrams of light-intensity. It is shown that under certain conditions the central concentration of light can be made of much smaller diameter, enabling a resolving power distinctly higher than the theoretical one to be attained. He thinks this will account for some of the "freak" resolutions that have been reported, and draws the attention of opticians to the ideals to be kept in view for different classes of work. He anticipates improved resolution for double stars. W. W. B.

93. *Nebular Lines in the Spectrum of the Long-Period Variable Star R Aquarii.* **P. W. Merrill.** (Mt. Wilson Observat., Contrib. No. 206. Astrophys. J. 53. pp. 375–379, June, 1921.)—*Discovery of Nebular Lines in the Spectrum.*—This star has a typical Md spectrum similar to that of about 85 per cent. of all long-period variable stars. In Oct. 1919 the bright nebular lines λλ4363, 4658, 4959 N_2, and 5007 N_1, and the helium line λ4471, which also occurs in nebulæ, were found to be superposed on the Md spectrum. Later observations have shown that these lines do not share in the changes of intensity exhibited by the light of the variable star, although they appear to emanate from the same object. *Intensities* and *displacements* of the Md and nebular lines are given in a table. AUTHOR.

94. *Bright and Dark Nebulæ near ξ Orionis.* **J. C. Duncan.** (Mt. Wilson Observat. Contrib. No. 209. Astrophys. J. 53. pp. 392–396, June, 1921.)—*Photographs* made with the 100-in. Hooker telescope of the Mount Wilson Observatory are reproduced in two plates. They exhibit the following features: the *bright nebulæ N.G.C.* 2024 and 2023 and *I.C.* 431, 432, and 434: the *dark cosmic cloud Barnard* 33, which indents or overlies the nebula I.C. 434; the *great disparity in the number of faint*

stars on opposite sides of a line passing nearly north and south through ζ Orionis; and a *striated appearance* in the faint nebulosity west of I.C. 434. Evidence is given of the existence of *four distinct types of extended masses* in the neighbourhood, and suggestions are made in explanation of the aspect of the region as presented by the photographs.
AUTHOR.

95. *Accuracy of Mean Parallaxes Determined from Parallactic and Peculiar Motions.* **H. N. Russell.** Mt. Wilson Observat. Contrib. No. 215. Astrophys. J. 54. pp. 140–145, Sept., 1921.)—Assuming that the stars in the group are all at practically the same distance and that the velocities are distributed according to Maxwell's law, it is shown theoretically that the probable errors in the mean parallaxes determined by the two methods are, respectively, $\pm 1\cdot035\bar{V}\pi/V_0\sqrt{n}$ and $\sqrt{0\cdot721}/\pi\sqrt{n}$. The ratio is $1\cdot44\ \bar{V}/\bar{V}_0$, and depends only upon the average value of the peculiar velocities, $\bar{V}$, since V_0 is the velocity of the sun. It follows that for Cepheids, stars of types A and B and others with peculiar velocities less than 14 km., the parallactic motions give the better result, while for stars moving faster the peculiar motions should be used. The formulæ also show that results of value may be obtained from rather small groups.

Statistical Study of 180 *Stars of Types* B0 *to* B5.—The mean *peculiar velocities*, radial and tangential, are 6·5 km. and 0″·0076; the *mean parallax* computed from parallactic motions is 0″·0083 (π_1), and from peculiar motions 0″·0058 (π_2). From π_1 and the *mean visual magnitude*, 4·08, the *mean absolute magnitude* comes out − 1·38. The probable errors for the determinations of parallax agree closely with those to be expected from the foregoing theory. The lower value of π_2 compared with π_1 is probably due to the inclusion of unknown binaries for which the observed peculiar motions are too large.
AUTHOR.

96. *Eclipsing Variable* 1 *H Cassiopeiæ, with Evidence on Darkening at Limb of a Stellar Disc.* **J. Stebbins.** (Astrophys. J. 54. pp. 81–91, Sept., 1921.)—*Variable Star* 1 *H Cassiopeiæ; photometric Study.*—Observations during 1917–1921 with a photoelectric photometer show that this star is an *eclipsing variable.* The primary and secondary minima have ranges of 0·132 and 0·032 mag. respectively, each with an interval of constant light showing that the eclipses are annular or total. From the *light-curve* are derived the *elements of the binary system*, which are in good agreement with the Allegheny spectroscopic results. There is, however, a discrepancy in the phase and duration of the secondary minimum which points to a *motion of the line of apsides*, and which, in view of the *high eccentricity*, $e = 0\cdot25$, could be readily verified by a new determination of the spectroscopic elements. The *density* of the smaller and fainter body is probably seven times that of the primary.

*Darkening at the Limb of a Star of Spectrum B*3.—This star furnishes an unusually favourable test for darkening at the limb, as there is an annular eclipse by a small companion; but the results indicate that there can at most be only a small fraction of the amount of darkening which is present in the case of the sun.

Comparison Stars, 1 *and σ Cassiopeiæ.*—These have been found to be constant in light, within perhaps 0·01 mag.

Photoelectric Photometer for Stars.—The *precision* which may be reached is indicated by the residuals for seventy-five normal magnitudes, which give the probable error of one normal = ± 0·0036 mag. AUTHOR.

97. *Calculation of Obliquity and Excess in the Distribution of Apparent Magnitude.* **K. G. Malmquist.** (Ark. f. Mat. Astron. och Fysik, Stockholm, 15. No. 9. pp. 1–11, 1921.—In German.)—The treatment is entirely mathematical, and follows Charlier. It is found that the obliquity and excess in the distribution of apparent magnitude are due mainly to the obliquity and excess in the absolute magnitude. L. H. W.

98. *Photometric Study of Y Camelopardalis.* **R. S. Dugan.** (Astrophys. J. 54. pp. 217–225, Oct., 1921.)—*Eclipsing Variable Y Camelopardalis.*—The 1035 *photometric observations,* in which B.D. + 76°·285 was used as comparison star are given in a table of 210 normals. The probable error of a single observation is ± 0·044 mag. The *light-elements* derived from the observations are in good agreement with Miss Harwood's conclusions concerning variation of the period. The *light-curve* shows the effects of ellipticity and reflection. A secondary minimum has been detected. The eclipses are partial and last about 12½ hours each. The range of variation is 1·73 mag. in primary minimum and 0·05 mag. in secondary minimum. "Uniform" and "darkened" *orbital elements* are collected at the end of the paper. In order to get a satisfactory "darkened" solution, it was necessary to assume that one side of the fainter star was entirely dark. AUTHOR.

99. *Spectroscopic Binary Boss* 3644, *Virginis.* **J. C. Duncan.** (Mt. Wilson Observat., Contrib. No. 212. Astrophys. J. 54. pp. 226–228, Oct., 1921.)—The *elements of the orbit* of this sixth-magnitude star of type F2 have been determined from 18 spectrograms. P is 2·6960 days, K is 24·3 km./sec., γ is 17·6 km./sec., and e is 0·00. A velocity-curve is given. AUTHOR.

100. *Wave-lengths and Periodic Changes of Spectral Type in the Variable Star l Carinæ.* **S. Albrecht.** (Astrophys. J. 54. pp. 161–190, Oct., 1921.)—Since the wave-lengths of many lines in stellar spectra change progressively with spectral type, it might be expected that in the case of a variable star periodic changes of wave-length might occur. A detailed study of *l* Carinæ shows this to be true. The results of measurements of 178 lines between λλ4236 Å. and 4495 Å., made on 17 three-prism spectrograms obtained at Lick Observatory, are given. In general, those lines which vary in wave-length with stellar type vary progressively from light-maximum to light-minimum, shifting by about 0·05 to 0·2 Å. The spectrum may not correspond to a pure type at any phase, but by taking the average of the types indicated by the different lines for each phase, it is found that the mean type varies from F8 near light-maximum to G9 near light-minimum. From this change of type a change of colour-index may be inferred which agrees with the changes observed or inferred for other Cepheids, showing that colour is correlated not only to the hydrogen spectrum, as others have found, but also to the general spectrum. Discrepancies between these results, based on changes of wave-length, and those of Adams and Joy, based on changes of relative intensity and width of lines, are discussed.

Relation of the Spectral Types of Cepheids to their Periods.—By tabulating the available data it is shown (1) that Cepheids are progressively of "later" type as the length of the period of light-variation increases; and (2) that the *range of variation of type* is about one type-interval and is independent of the period. AUTHOR.

101. *Orbit of* 49 δ *Capricorni.* **C. C. Crump.** (Astrophys. J. 54. pp. 127–132, Oct., 1921.)—*Elements of the orbit of* 49 δ *Capricorni* have been determined with considerable accuracy from 74 spectrograms taken with the Bruce spectrograph at Yerkes Observatory. The period is 1·02275 days, and K is 65·7 km./sec. AUTHOR.

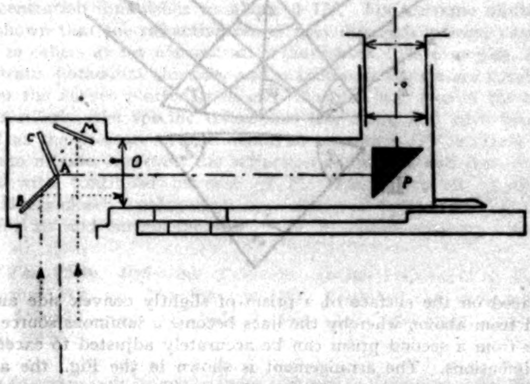
102. *Comparison of Proper Motions.* **C. C. Comstock.** (Astron. J. 33. pp. 177–178, Aug. 5, 1921.)—In view of a list of proper motions to be included in a volume of Publications of the Washburn Observatory, the author gives a preliminary comparison with the Greenwich Catalogue for 1910. Eighteen stars are common to the two lists, and a list of differences in the centennial proper motions shows a maximum of about 5" per century, which he thinks may fairly be attributed to the old observations of Lalande and Bessel, on which the Greenwich figures are based to a great extent, and not on the Greenwich observations, nor on the Washburn ones. He shows a close accordance between *a priori* estimates of probable error, and the actual residuals. W. W. B.

103. *Aurora Borealis of May* 13, 1920. **C. Störmer.** (Comptes Rendus, 172. pp. 1672–1673, June 27, 1921.)—Amongst the photographs of this aurora is a pair of special interest, taken simultaneously at Kristiania and Oscarsborg (27·36 km. apart) at 11h. 4m. 24s. G.M.T. It represents a long auroral ray, the position in space of six points of which have been determined. The heights of these points above the earth's surface range from 192 km. to about 470 km., and the ray is thus remarkable for the high altitude of its lowest point as well as for the fact that it reached a level of almost 500 km. During a previous aurora, March 22–23, 1920, the summits of the rays were found to be between 500 km. and 600 km. M. A. G.

LIGHT.

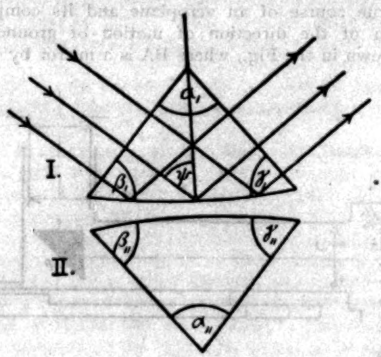
104. *Apparatus for Measuring Aberrations of Objectives.* **A. Wetthauer.** (Zeits. Instrumentenk. 41. pp. 184–187, June, 1921. From the Physikal.-Techn. Reichsanstalt.)—Describes a convenient form of instrument for the ready determination of the spherical and chromatic aberrations of an objective, using Foucault's method. A description of this method and that of Hartmann is given in the paper. The method is only applicable for wave-lengths from about 430 to 660$\mu\mu$. J. W. T. W.

105. *Instrument for Determining True Course of an Aeroplane in Flight.* **Barbillion** and **M. Dugit.** (Comptes Rendus, 173. pp. 492–494, Sept. 19, 1921.)—Describes an optical device for determining the angle between the true course of an aeroplane and its compass course, by the observation of the direction of motion of ground objects. The apparatus is shown in the Fig., where BA is a mirror by which an object is seen directly in a telescope (objective O, and eyepiece *o*) while a second image of the same object is seen through the mirrors M and CA. The line of intersection of the mirrors BA and CA divides the field of view symmetrically and so long as this line is parallel to the true course of the machine, the two images of passing objects are seen neither to diverge nor to converge. Owing to oscillations, when the line is correctly set, there is continual convergence and divergence, and this position gives, from a graduated dial reading directly the angle between the line A and the axis of the machine, the actual deviation of the true from the compass course. J. W. T. W.



106. *Infra-Red Transmission Characteristics of Organic Oils and Other Substances.* **W. W. Coblentz.** (Bureau of Standards, Bull. 17. pp. 267–276 [Sci. Papers No. 418], 1921.)—Gives the transmission curves from $0 \cdot 6\mu$ to 3μ of olive oil, cottonseed oil, peanut oil, tung oil, catfish oil, lard oil, fatty acids of linseed oil, pure linseed oil, oleic acid, glycerine, three samples of nitrocellulose, benzol, bakelite, paraffin oil, and selenite. As in previous investigations at greater wave-lengths, it is found that this region of the spectrum is also unsuitable for the spectroradiometric detection of animal and vegetable oils of similar composition. The spectroradiometer used consisted of a mirror spectrometer, a quartz prism, and a vacuum thermopile. In an appendix to the paper figures are given for the wave-length corrections to be applied to the maxima of absorption bands for rock-salt published in 1905. These do not in any case exceed $0 \cdot 03\mu$. J. W. T. W.

107. *Limit of Application of the Law of Refraction.* **P. Fröhlich.** (Ann. d. Physik, 65. 7. pp. 577–592, Sept. 27, 1921.)—The sine law of refraction does not hold when the source of light is very close to the refracting surface. The author describes a device, consisting of two fine lines traced on the surface of a prism of slightly convex side and illuminated from above, whereby the lines become a luminous source whose distance from a second prism can be accurately adjusted to exceedingly small dimensions. The arrangement is shown in the Fig., the angle ψ being at the trace of the luminous line. The distances used were from 15×10^{-4} down to $2 \cdot 5 \times 10^{-4}$ mm. and the extreme angles at which the source was visible at these distances were from 41° to 78°, the angle of total reflection being 38°. The results are tabulated and exhibited graphically in the paper. J. W. T. W.



108. *Infra-Red Transmission and Refraction of Standard Lens and Prism Material.* **W. W. Coblentz.** (Bureau of Standards, Bull. 16. pp. 701–714, 1920.)—Gives a general resumé of the data available on the optical constants of glass, CS_2, quartz, fluorite, rock-salt and sylvite. In a figure are given the dispersive powers of these materials, and from this it is seen that for the region $0 \cdot 5$ to $1 \cdot 5\mu$ a carbon disulphide prism is most useful for producing a large dispersion. Quartz is most useful in the region from the visible to $3 \cdot 8\mu$. From the standpoint of dispersion and transparency a fluorite prism is most useful from 2 to 9μ, but rock-

salt allows measurements to 14μ when using a 60° prism and to 16μ when using a 30° prism. Sylvite is most useful from 10 to 20μ.
J. W. T. W.

109. *Spectrophotoelectrical Sensitivity of Proustite.* **W. W. Coblentz.** (Bureau of Standards, Bull. 17. pp. 179–186 [Sci. Papers, No. 412], 1921.)—The present investigation is a continuation of previous work on the spectrophotoelectrical sensitivity of various substances. At 20° C. the spectrophotoelectrical sensitivity curve of proustite has a slight maximum at about $0 \cdot 61\mu$ and a marked sensitivity with a wide maximum (at about $0 \cdot 3\mu$) in the ultra-violet. At $-170°$ C. the intrinsic spectrophotoelectrical sensitivity is greatly increased; but the max. reaction is confined mainly in a sharp maximum at $0 \cdot 578\mu$. No photoelectrical sensitivity was observed for radiation stimuli of wave-lengths extending from $0 \cdot 7\mu$ to 2μ. AUTHOR.

110. *Variation of the Specific Refraction of Dissolved Salts in Dilute Solutions.* **C. Chéneveau.** (Comptes Rendus, 172. pp. 1408–1410, June 6, 1921.)—It was shown previously [Abs. 1595 (1910)] that the specific refraction, $(n_D - 1)/d$, of a dissolved salt remains constant while the concentration diminishes to about $0 \cdot 1N$. For extreme dilutions it is now shown that the refractive power may diminish in some cases and increase in others as the concentration diminishes. As examples, ammonium nitrate, potassium chloride, and magnesium nitrate are considered, and from the curves plotted it is seen that the last two of these salts behave similarly, the specific refractions increasing and then becoming constant as the pressure of the dissolved substance (P) increases; with ammonium nitrate, however, the refraction diminishes and then becomes constant with continued increase of P. The behaviour of the two former salts is closely analogous to that observed by Posejpal [Abs. 1246 (1921)] for air and carbon dioxide. T. H. P.

111. *The 72-in. Reflecting Telescope for the Dominion of Canada.* (Engineering, 112. pp. 207–209 and 222, Aug. 5; 240–244, Aug. 12, and pp. 269–272, Aug. 19, 1921.)—Illustrated description. [See also Abs. 1061 (1920).]

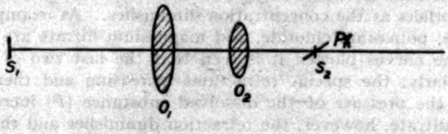
112. *Accuracy of the Internally Focusing Telescope.* **T. Smith.** (Phil. Mag. 41. pp. 890–899, June, 1921.)—Gives formulæ by means of which calculations can be carried out on a slide-rule. L. H. W.

113. *The Colours of Mixed Plates.* **C. V. Raman** and **R. Banerji.** (Phil. Mag. 41. pp. 860–871, June, 1921.)

114. *Effect of Gravitation on Light.* **H. Jeffreys.** (Phil. Mag. 42. pp. 470–471, Sept., 1921.)—The query in Lodge's note [Abs. 1708 (1921)] concerning the legitimacy of deriving the equations $r\,dt/ds = h$ and $r^2 d\theta/ds = h$ for the motion of a light-wave is relevant to Jeffreys' paper on the "Crucial tests of Einstein's theory of gravitation" [Abs. 515 (1920)]. He derived them as two of the conditions that a principle of least action should be satisfied for the path of a particle. To assume that the same equations hold for a light-wave is to say that the motion of a light-wave is the *limit* of that of a particle when the velocity at a great distance from the sun tends to that of light. It is suggested that this is a natural hypothesis to make, and that Einstein's law is the only reasonable one that makes it fit the observations. It may not be obviously true *a priori*, but it appears highly probable. A. W.

115. *Collection of Technical Data with the Help of Photography.* **A. Worischek.** (Elekt. Zeits. 42. pp. 431–433, April 28, 1921.)—This work was undertaken to meet the need of those who would find a portable, cheap, and easily worked photographic apparatus useful in copying illustrations, articles, etc., from books in libraries. Numerous references are given to the work of others in the same or similar fields, as are details of the author's experimental work. A. E. G.

116. *Crossing Image Method of Testing Photographic Objectives.* **A. Wetthauer.** (Zeits. Instrumentenk. 41. pp. 148–152, May, 1921. From the Physikal.-Techn. Reichsanstalt.)—The method is seen from the diagram in which S_1 is an object, consisting of two parallel slits placed at the focus of O_1 or collimator lens. O_2 is the objective under test and P_h is a photographic plate placed at an angle of 10° with the axis of the system. In this way the exact position of the focus of O_2 for light of any wave-length is found by the position of intersection of the images of the two slits formed on P_h. The spherical aberration due to each zone of O_2 is similarly found by placing stops in such a way as to interrupt all the light except that passing through the zone of O_2 under consideration. J. W. T. W.



117. *An Extension of the Theory of Babinet's Compensator.* **C. A. Reeser** and **R. Sissingh.** (K. Akad. Amsterdam, Proc. 24. 1, 2, and 3. pp. 102–107, 1921.)—In employing Babinet's compensator for the examination of elliptically polarised light the principal planes of the two wedges must be at right angles to each other, and if the elliptically polarised light arises from reflection, one of the principal planes must coincide with the plane of incidence of the mirror. To satisfy this condition new extinction phenomena, not previously observed in the compensator, can be employed with enhanced accuracy in the adjustment of the compensator. The phenomena in question are experimentally studied and theoretically confirmed. A. B. C. L.

118. *Fifth-Order Aberrations in Symmetrical Optical Systems.* **A. Sonnefeld.** (Zeits. Instrumentenk. 41. pp. 259–261, Sept., 1921.)—Petzval gave the number of independent fifth-order aberrations in a symmetrical system of spherical surfaces as twelve in number; Schwarzschild, however, as nine. The author discusses the various contributions which have subsequently been made to this subject, and concludes that the number is really nine. J. W. T. W.

119. *Wave Theory and Geometrical Optics.* **L. Dunoyer.** (J. de Physique et le Radium, 2. pp. 258–264, Aug., 1921.)—The author takes the view that the use of the wave theory for establishing results usually obtained by geometrical optics gives a much better insight into the subject. Two examples are given of the use of a "wave" method. The first of these gives a simple derivation of the aplanatic points of a sphere, and the second, a little more complicated, shows how the focal points for a spherical refracting surface may be obtained. A. W.

120. *Optical Investigation of Surface Layers on Mercury and a More Refined Method of Observation with Babinet's Compensator.* **C. A. Reeser** and **R. Sissingh.** (K. Akad. Amsterdam, Proc. 24. 1, 2, and 3. pp. 108–113, 1921).—Experiments are described made with the apparatus employed by Haak [see Abs. 717 (1919)] with modifications of which details are given. The results obtained with surface layers of smoke, air, and oil are given and discussed. A. B. C. L.

121. *Natural and Magnetic Rotatory Dispersion of Optically Active Transparent Liquids.* **E. O. Hulbert.** (Astrophys. J. 54. pp. 116–126, Sept., 1921.)—From the electron theory of H. A. Lorentz a *theoretical formula* is derived for the rotatory power of an optically active medium placed in a magnetic field, neglecting the effect of absorption of light in the medium. To test the theory, *measurements of the angles* of rotation were made for *limonene* and for solutions of *cane sugar* in water, of *tartaric acid* in water, and of *camphor* in ethyl alcohol, using plane-polarised monochromatic light of *from* 436 to $620\mu\mu$ and a field strength of 6480 gauss. The formula was found to agree with the results for natural rotation in each case. It could be compared with magnetic rotation measurements only in the case of the sugar solution, and then agreement was found for the longer wave-lengths; for the shorter ones, however, the theoretical values are somewhat too great. The discrepancy is attributed to the neglect by the theory of the effect of absorption.

Refractive indices for limonene and for one to one solutions of cane sugar and tartaric acid in water and of camphor in ethyl alcohol, $436–620\mu\mu$, were determined. AUTHOR.

122. *Spectra of Argon, Krypton, and Xenon.* **W. F. Meggers.** (Bureau of Standards, Bull. 17. pp. 193–202, 1921.)—Gives the values of 50 wave-lengths in the spectrum of argon, 18 of krypton and 12 of xenon, obtained by comparison with the international primary standard by means of étalon interferometers. The error is considered to be of the order of 0·001 Å. in most cases. From wave-length measurements in argon and krypton frequency differences are obtained which are constant within the probable error of the measurements, thus giving further confirmation of the Combination Principle of Ritz. As the heavy rare gases cause sputtering of the electrodes on to the walls of the tube with hardening of the tube, it was not found possible to measure the fainter lines of xenon, and this work is to be carried out when more tubes are available. J. W. T. W.

123. *Obliteration of the Characteristic Spectra of Metals by Certain Gases.* **G. E. Gibson** and **W. A. Noyes, Jr.** (Am. Chem. Soc., J. 43.

pp. 1255-1261, June, 1921.)—Numerous experiments were carried out with flame and, particularly, with spark spectra and it was found that certain gases have the power of diminishing the intensity of the characteristic spark spectra of metals. The gases which have this power have also a high sparking potential relative to air. They are also, in general, the gases which, on Lewis' theory of molecular structure, we should expect to have the power of combining readily with electrons, or which dissociate in the spark into gases of this character. The parallelism between high sparking potential and power to obliterate the spectrum lines is explained if we assume that the molecules of gases which have these two properties unite with free electrons to form ions of larger mass which are incapable of producing further ionisation. [See Abs. 777 (1911).] A. W.

124. *Theory of the Abnormal Zeeman-Effect.* **P. Das.** (Calcutta Math. Soc., Bull. 12. pp. 67-78, Sept., 1921.)—Sommerfeld [Abs. 52 (1917)], using Bohr's atomic model, applied the quantum theory to account for the normal Zeeman-effect, but his treatment had no marked advantage over the classical electromagnetic theory, in so far as the Zeeman-effect is concerned. Sommerfeld's paper is open to criticism since he neglected the squares of the magnetic field. In the present mathematical paper it is shown that these terms are responsible for the asymmetry observed by Gmelin and Dufour. An atomic model is described, which, though somewhat speculative in character, explains Runge's law of multiple resolution. This law may be stated thus: The distances of the lines from the central component are exact multiples of an aliquot part of the normal resolution. An extension of the dynamics of the $+H_2$ ion leads to the result that a part of the secondary spectrum of hydrogen should not show the Zeeman-effect. The paper concludes with an investigation of the dynamical features of a hydrogen atom in a magnetic field, taking relativity into account. In a subsequent paper the intensity and polarisation of the lines will be dealt with. A. W.

125. *Wave-Length Measurements in Arc Spectra Photographed in the Yellow, Red, and Infra-Red.* **F. M. Walters, Jr.** (Bureau of Standards, Bull. 17. pp. 161-177 [Sci. Papers, No. 411], 1921.)—For several years the Bureau of Standards has been conducting grating measurements in red and infra-red arc spectra by the aid of specially sensitised photographic plates to improve the data in this region and to find some element which would furnish lines suitable for wave-length standards in this region. To the 25 elements already measured the following are here added: Silver, aluminium, gold, bismuth, cadmium, mercury, lead, antimony, tin, and zinc. The wave-length measurements are in the international system and are given to 0·01 Å. The elements were brought to luminosity by inserting a sample in copper or graphite electrodes between which the arc was maintained. The grating used had 299 lines per mm. and a 640-cm. radius. The spectra were photographed in the first order on plates sensitised with pinacyanol or dicyanin. The comparison spectrum was iron in the first, second, or third order, and in the reductions the wave-lengths established by interference methods were used.

Impurity and spurious lines must be looked for very carefully. It is necessary to describe exactly the source of light and specify the observing conditions. The accuracy possible in wave-length measurements from the direct photography of normal spectra exceeds that in measurements from phosphor photography and bolometer measurements.

AUTHOR.

126. *Fine Structure of Band Spectra.* **E. Gehrcke** and **L. C. Glaser.** (Ann. d. Physik, 65. 7. pp. 605–608, Sept. 27, 1921. From the Physikal.-Techn. Reichsanstalt.)—Certain lines of Mg, Hg, and C were examined by an interference method which allowed the fine structure to be photographed. The source of light was an arc between electrodes of Mg, Hg, or C, operated at pressures below 1 mm. of mercury, hydrogen being introduced into the arc chamber in the case of magnesium. The light fell on a plane-parallel glass plate of 5 mm. thickness, and the interference bands were projected by lenses on to the slit of a prism spectrograph, as in Galli and Försterling's arrangement [Abs. 642 (1917)]. The slit was arranged perpendicular to the interference bands. Photographs are given of the spectra thus obtained, in which each line is traversed by interference minima. Magnesium gave the sharp lines λ5529 and λ4703, the more diffuse lines λλ5184, 5173, 5167, and 4352, and finally, on the violet side of the green triplet, part of the band spectrum. The band lines are sharp, and are distinguished by their very regular sequence, so that slanting curves are obtained in the photographs, giving a "shot silk" effect similar to that observed by Wood in the spectra of titanium and iron. It is to be noted that the heads of the bands, contrary to the sharp lines such as λ5529, show interference points with slanting indications. The band heads must therefore contain components which are still unresolved. Similar effects were observed with Hg. In this case, at about λ4170, the "shot silk" effect exhibits curves similar to parabolas, which probably signifies a symmetrical sequence of band lines. With carbon, which gives a band spectrum with very narrow bands, the heads of the bands are not so sharp as in the case of Hg and Mg. To investigate this spectrum a higher resolving power or additional plane-parallel plates will be necessary. A. W.

127. *Induction Spectrum of Rubidium,* **λ2294** to **λ5525.** **L. Dunoyer.** (Comptes Rendus, 173. pp. 472–474, Sept. 12, 1921.)—In a previous paper [Abs. 1912 (1921)] a method was described for exciting luminescence in the vapours of cæsium and rubidium, using a high-frequency electromagnetic field. The present paper gives a table of the lines thus obtained with rubidium. 332 lines have been measured between λ2294 and λ5525. Nearly all the spark lines measured by Exner and Haschek or by Lockyer are found amongst the most intense of the lines given. Temperature effects similar to those found for cæsium were observed. At 100° C. there was an intense blue-violet luminescence, which suddenly changed at a certain temperature. At 200° C. the colour was lilac. It was found that these changes of colour are related to the length of the spark passing between the terminals of the coil feeding the Tesla circuit. The wave-length table given was obtained with the tube at 120° C., the luminescence being then blue-violet. The only lines belonging to a known series are the lines λ4201·0 and λ4214·4, which constitute the second doublet of the principal series. All the other arc or flame lines are absent. These two lines, again, have a feeble intensity, and disappear altogether if the vapour pressure is increased. Some of the spark lines appear to be missing in the induction spectrum. Among these are the lines λλ3353·5, 3833·9, 3843·8, 3846·3, and 4029·6. A. W.

128. *Symmetrical Groups of Lines in the Spectrum of Iron.* **E. Gehrcke.** (Ann. d. Physik, 65. 7. pp. 640–642, Sept. 27, 1921.)—Glaser has recently published an account and photographs of the violet part of the iron spectrum. An examination of these results shows the existence of numerous groups of lines symmetrically arranged on either side of some particular wave-length. In some of these groups the lines of greatest intensity lie farthest from the common centre, in other groups the lines near the centre are the most intense. Diagrams of six such groups are given. It is interesting to note that the individual groups are not completely independent, but are linked with one another; thus, both the outer components of group A and its left inner component belong also to group B. Irregularities in the intensity of symmetrically situated components find an explanation in the fact that the lines belong to different groups. *Addendum by corrector.*—In a later paper by Glaser spectrograms of tungsten and molybdenum are given, and these also show a number of symmetrical, coupled groups of lines. The line groups are thus not confined to the iron spectrum. A. W.

129. *The Spectrum of Fluorine.* **W. R. Smythe.** (Astrophys. J. 54. pp. 133–139, Sept., 1921.)—*Preparation of Fluorine Gas by Electrolysis of Fused Potassium Acid Fluoride.*—The method due to Mather and others of the Chemical Warfare Service is described, together with the necessary apparatus. The gas was purified by passing through sodium fluoride and a freezing trap. To protect the pump a charcoal trap was inserted.

Visible and Ultra-Violet Spectrum of Fluorine and Carbon Tetrafluoride.—A dozen previous researches had failed to determine definitely the lines due to fluorine because of impurities in the gas used. In this research a spectrum with foreign lines absent or very weak was obtained by flowing practically pure fluorine gas at atmospheric pressure continuously through a discharge tube with gold electrodes. Although the tube had a fluorite window, put on in optical contact without cement yet practically airtight, and both a quartz spectrograph and a 50-cm. concave grating were used, the only fluorine lines found were ten between λ6239 and λ7034. The *wave-lengths* of these lines, determined to about 0·1 Å., are given and also the approximate positions of the heads of nine bands presumably due to CF_4, between λ4829 and λ6525. AUTHOR.

130. *Magnesium Spectrum; Part Played by Electric Fields in the Emission.* **A. de Gramont** and **G. A. Hemsalech.** (Comptes Rendus, 173. pp. 505–511, Sept. 26, 1921.)—This paper is concerned with the part played by electric actions in the emission and appearance of certain types of lines in the spectrum of magnesium. Preliminary experiments on the appearance of spark lines of lead and tin in the electric arc led to the conclusion that the emission of these lines is connected with the existence of intense electric fields [Abs. 1981 (1921)]. The methods employed in the present work were the same as previously employed, i.e. blowing the arc, wetting the electrodes with different liquids, cooling by liquid air, and employing different gaseous media. The electrodes were arranged so that the displacement of the upper electrode took place parallel to the slit of the spectrograph. It was thus possible to follow the different phases of the phenomena. The liquids used were distilled water, glycerine, and petrol. The two first contain oxygen, and with these it was possible to observe optical effects resulting from chemical reactions during the first phase. It was found that the line **λ4571**, as well as the band at **λ5007**, attributed generally to magnesium oxide, are emitted strongly both with layers of water and of glycerine, but very feebly with a layer of petrol. During the second phase, when the discharge is influenced by air, both the line and the band are well developed in the three cases. Under the same conditions, the emission of the triplets is not affected by the nature of the liquid, except that in the arc with a drop of water they appear broadened. The Rydberg diffuse series lines are absent or very weak in the case of petrol, but strongly developed when water or glycerine is used. These lines have a tendency to be broadened towards the red, this effect being particularly noticeable in the first phase of the arc with water. The spark lines are emitted during the first phase with all three liquids. The line **λ4481**, in particular, reaches a great intensity in the first phase, comparable to that observed for this line in a capacity spark. During the second phase the intensity and width of this line decrease rapidly, and at a certain instant the intensity is suddenly reduced. Similar effects have been observed in the case of cadmium spark lines. The paper concludes with a discussion of the results, from which it appears that intense electric fields are developed in the first phase of the arc. A. W.

131. *Ultra-Red Absorption Spectra of Solid Substances in Thin Layers.* **O. Reinkober.** (Zeits. f. Physik, 5. 2 and 3. pp. 192–197, 1921.)—For the spectroscopic examination of solid substances in the ultra-red the author, instead of using the customary reflection method, has made direct observations by a simple absorption method. On account of the opacity to ultra-red of the substances under investigation, it was found necessary to prepare the specimens in extremely thin layers by condensing the vapour of the heated substance on a plate of another substance which was transparent to the ultra-red rays. In this manner, the author has obtained the absorption spectra of the ammonium halides in the wave-length region up to 8μ. A. B. W.

132. *Anomalous Zeeman-Effect.* I. **A. Landé.** (Zeits. f. Physik, 5. 4. pp. 231–241, 1921.)—The quantum theory of the normal Zeeman-effect (Sommerfeld, Debye) requires a series of determined directions of the atom axes with respect to the direction of the magnetic field. Now since, in the case of simple lines, the equatorial impulse is connected with the magnetic energy by a single constant factor, the same energy step always corresponds to all permissible impulse quanta steps (normal triplet). In the case of doublets and triplets, however, each proportionality factor has different individual values for the different terms. The permissible impulse quanta steps lead, therefore, to a series of different energy steps, which in the anomalous Zeeman-effect are observed side by side. Each observed p- and s-component is associated with a definite transition of the azimuthal quantum number n, the inner quantum number *k*, and its equatorial component *m*. Predictions are made with regard to the hitherto unobserved Zeeman types of Bergmann series and Stark's diffuse principal series. The problem of the anomalous Zeeman-effect is thereby reduced to the question of the origin of these variable factors, which can be conceived as anomalous e/m values. [See Abs. 433 (1921).] A. W.

133. *Influence of Increased Temperature on the Fluorescence- and Absorption-Spectra of Iodine Vapour of Constant Density.* **P. Pringsheim.** (Zeits. f. Physik, 5. 2 and 3. pp. 130–138, 1921.)—When the vapour density of iodine vapour is increased a sudden change of colour, from green to yellow, occurs in the fluorescence spectrum; this effect being the result of increased secondary absorption in the short-wave part of the band-spectrum. A phenomenon, wholly similar to this, has been observed when a pure temperature increase takes place in the iodine vapour (density constant). In this case there is decreased primary absorption, followed by decreased fluorescence emission in the affected part of the spectrum.

Heating the iodine vapour at constant density not only produces an intensity displacement in the whole absorption spectrum, but also results in marked changes in the energy-distribution of individual bands. A. B. W.

134. *Fluorescence of Mercury Vapour.* **J. S. van der Lingen** and **R. W. Wood.** (Astrophys. J. 54. pp. 149–160, Oct., 1921.)—*The fluorescent spectrum of mercury vapour* cannot be excited in quiescent vapour, but only in vapour which is being distilled from the metal at a temperature of 150° or more. This proves that the *active molecules* are not neutral monatomic molecules but others present only during distillation, perhaps diatomic molecules. The spectrum consists of three lines—λ2536, 2539, and 2346 Å., and four structureless bands with maxima at 2346, 2540, 3300, and 4850 Å. While the complete spectrum is excited by light from a zinc spark, single lines excite only part. *The relation of the spectrum to the exciting light* is of great interest. The broad bands with maxima at 3300 and 4850 may be excited, with varying relative intensity, by λ1854–62, 2346, or 2536–40 Å.; whereas the band λ2346–2100 Å. is excited only by λ2000–2150 Å., the position of the maximum depending on the particular wave-length used. All the effective exciting lines lie, of course, in the absorption spectrum of mercury vapour. AUTHORS.

135. *X-Ray Dosage with Special Reference to the Barium Platinocyanide Pastille.* **E. A. Owen** and **P. K. Bowes.** (Röntgen Soc., J. 17. pp. 107–117; Disc., 117–119, July, 1921.)—An account is given of the measurement of the intensity of a beam of X-rays emitted by a Coolidge bulb, by the ionisation method and by the change of tint of a barium platinocyanide pastille. The results obtained show that the indications of the pastille follow those of the electroscope in every instance, and the agreement is close when the change of tint of the pastille is measured by means of a tintometer. The product of the ionisation per minute given by the electroscope and the time of dose given by the pastille (i.e. the time taken to change from one definite tint to another) is a constant. This relation was found to be independent of the current through the bulb, type of interrupter, frequency of interruption, interval between "make" and "break," and voltage of primary current. For the coil outfit employed in the investigation the relation between the ionisation (I) per minute and the other variables was found to be $I = kn^{s} V^2 \{C/(C+\psi)\}$, where n is the frequency of interruption of primary current, V the voltage on the bulb, C the mean current through the bulb as given by the milliammeter, k a constant whose value depends upon the distance of the electroscope from the antikathode, and ψ a function whose value is nearly constant. E. A. O.

136. *The Law of Photochemical Action of X-Rays.* **R. Glocker and W. Traub.** (Phys. Zeits. 22. pp. 345–352, June 15, 1921.)—The authors point out that whilst the relation of photochemical reaction to intensity, wave-length, time of exposure, and methods of development are known for light-rays, little is known regarding the similar relations for X-rays, with the one exception of a paper by Friedrich and Koch who used very long exposures, whereas for a complete delineation of the photochemical curve a different experimental arrangement permitting the use of smaller exposures is required. The present paper is concerned with: (1) Determination of the photochemical action as a function of exposure time for definite wave-lengths and methods of developing; (2) variation of the photochemical effect as a function of variable wave-length; (3) determination of the photochemical effect as a product of intensity and time (Bunsen's law).

A particular photometer arrangement for use with a Coolidge tube is described in detail, together with the particular materials used to reflect the radiations and the methods used in developing the plates. The photochemical effect, S, is defined by the relation $S = \log_{10}(I_0/I)$, where I_0 and I are, respectively, the intensities of the incident and the transmitted light upon the plate, measured by a thermopile. Curves are then given for the relation of photochemical effect as a function of exposure time, and the authors find that the straight-line course, given for this curve by Friedrich and Koch, holds; it differs, however, from the similar light-curve by there being no threshold time value below which an effect is not given.

Experiments are described for determining the curve as a function of wave-length, and as a result it was found the effect of radiations was essentially the same, whatever the wave-length.

The law of photochemical action for light can be expressed by the relation $it^p =$ constant, where i is the intensity of light, t the time of exposure, and p a constant which Lembach has found to vary from 0·85 to 0·95. For non-homogeneous X-rays a similar relation was shown to hold by Kroncke, but the value of p is nearly unity and never falls below 0·96. The present authors have confirmed this law for homogeneous X-rays and find that p does not differ greatly from unity and is $0{\cdot}98 \pm 0{\cdot}01$. The product of intensity and time hence gives somewhat greater darkening at great intensities; this, however, can usually be neglected, the variation from the Bunsen law, $I \times t =$ constant, being small.

The authors summarise as follows:—

1. The photochemical effect of X-rays, in contrast to that of light, has no threshold value.

2. With Hauff X-ray plates and Adurol developer at 18° C. the

course of the curve of photochemical effect as a function of both time and intensity is exactly linear until a value $S = 0 \cdot 6$ is reached, when the effect diminishes slightly as a function of time until at $S = 1 \cdot 3$ it is exactly proportional to the logarithm of the time.

3. Within the wave-length range $\lambda = 1 \cdot 1 - 0 \cdot 4$ Å, all wave-lengths give an equal effect.

4. The Bunsen reciprocal law is found to be nearly correct. B. J. L.

137. *Intensity of X-Ray Reflection by Diamond.* **W. H. Bragg.** (Phys. Soc., Proc. 33. pp. 304–311, Aug., 1921.)—Describes an investigation of the relative intensities of the reflections of monochromatic X-rays by the various crystallographic planes of diamond. The special difficulties due to the small size of available crystals and the modification of the usual method required to obviate them are discussed. An interesting feature of the results is that they lie very closely on smooth curves, which indicates that if the outer electrons of the carbon atom lie at any considerable distance from the centre they must be in motion over a wide range, or for some other reason must contribute little to the reflection.

It is shown that the properties of the carbon atom in diamond are based on a tetrahedral and not a spherical form. The tetrahedra point away from any (111) plane in the case of half the atoms, and towards it in the case of the other half. Consecutive 111 planes are not exactly of the same nature and consequently some slight second-order reflection from the tetrahedral plane might be expected. This effect, though slight, has been found. AUTHOR.

138. *Reflection of the X-Ray Spectrum of Palladium from Fluorspar.* **H. Pealing.** (Phys. Soc., Proc. 33. pp. 297–303 with Disc., Aug., 1921.)—An examination of the odd-order spectra reflected from the 100 plane of fluorspar, using palladium X-rays, has been made with a view to test the Lewis-Langmuir theory of the motion of valency electrons in compounds. Evidence has been obtained which is in partial confirmation of the theory. AUTHOR.

139. *Fine Structure of X-Ray Series.* **D. Coster.** (Comptes Rendus, 173. pp. 77–79, July 11, 1921.)—The author discusses certain peculiarities observed in the spectral series of the heavy elements Ta to Ur. Particular reference is made to the relative intensities of certain of the series lines, notably γ_6, γ_2, and γ_3. A. B. W.

140. *Emission and Absorption Wave-Lengths of the Characteristic Radiation in the* L *Series.* **D. Coster.** (Phys. Rev. 18. pp. 218–220, Sept., 1921.)—*Wave-lengths of the lines* $L_{\beta 5}$, $L_{\gamma 2}$, *and* $L_{\gamma 4}$ *of the X-ray spectra of W, Pt, Au, Tl, Pb, Bi, Th, and Ur* have been measured by an improved photographic method developed by Siegbahn, for comparison with the corresponding absorption lines L_{a1}, L_{a2}, and L_{a3} measured by Duane and Patterson.

Test of Stokes' Law as Applied to X-Radiation.—The conclusion of Duane and Patterson that contrary to Stokes' law the absorption wave-lengths are in some cases longer than the corresponding critical emission wave-lengths is found not to be true for any of the elements from Pt to Ur. In the case of W there is a discrepancy, but this may be attributed to the effect of the characteristic radiation from the W target used. AUTHOR.

141. *Fine Structure of X-Ray Spectra.* II. **A. Sommerfeld.** (Zeits. f. Physik, 5. 1. pp. 1–16, 1921.)—E. Hjalmar has shown [Abs. 1176 (1920)] in a series of precision measurements of the K series that the lines K_α and K_β have, for the light elements, more weak satellites. In the present paper the author discusses the theoretical significance of the satellites of K_β, but declines to express an opinion in regard to those of K_α. A. B. W.

142. *X-Ray Research by the Debye-Scherrer Method; Length of Side of Elementary Lattice of Mo.* **P. Stoll.** (Arch. des Sciences, 3. pp. 546–547, Sept.–Oct., 1921. Paper read before the Soc. Suisse de Physique.)—The author determines by the Debye-Scherrer powder method the structure of molybdenum. The length of the side of the elementary cubical lattice is given as $3 \cdot 08 \times 10^{-8}$ cm. A brief reference is also made to an investigation of the coagulation of colloidal gold. A. B. W.

143. *Absorption-Loss through Internal Scattering in Matter.* **R. Glocker** and **M. Kaupp.** (Phys. Zeits. 22. pp. 200–209, April 1, 1921.)—A theoretical discussion of the possible internal scattering in a substance exposed to a beam of X-rays. The cases considered are those of normal incidence and of a finite angular breadth of the incident beam. A. B. W.

144. *X-Ray "Bremsstrahlung."* **A. March.** (Phys. Zeits. 22. pp. 209–213, April 1, 1921.)—A mathematical paper not permitting of a short abstract. A. B. W.

RADIO-ACTIVITY.

145. *Parent of the Ur and Ac Series.* **A. Piccard** and **E. Stahel.** (Arch. des Sciences, 3. pp. 541–543, Sept.–Oct., 1921. Paper read before the Soc. Suisse de Physique.)—Contrary to the general opinion that the actinium series is a lateral branch of the Ur-Ra family, one of the authors has put forward the hypothesis that UrY is produced by an independent isotope of uranium, namely AcU. Assuming an atomic weight of 235 for this substance, then that of AcD should be 207. To elucidate this and other points arising from Piccard's theory the authors have carried out a series of investigations to which reference is made in the present paper. Their observations appear to confirm the hypothesis of two AcU's. The actinium family commences, therefore, by the following substances:

$$\mathrm{AcUI}(239) - \alpha - \mathrm{UV}(235) - \beta - \mathrm{UZ}(235) - \beta - \mathrm{AcUII}(235)$$
$$- \alpha - \mathrm{UY}(231) - \beta - \mathrm{Pa}(231) - \alpha - \mathrm{Ac}(227).$$

As a mean of 14 observations (varying between 24·20 and 24·80) the authors obtain a value $T = 24 \cdot 52 \pm 0 \cdot 05$ days for UX; and as a mean of 12 observations (1·152 to 1·122)$T = 1 \cdot 138 \pm 0 \cdot 003$ minute for UX_2.

Reference is also made in the paper to observations relating to the constancy of radio-activity on the ground, under the ground, and at different altitudes. A. B. W.

146. *Tracks of α-Particles Emitted by Actinium Emanation and ActA.* **S. Kinoshita, H. Ikeuti,** and **M. Akiyama.** (Phys. Math. Soc. Japan, Proc. 3. pp. 121–133, Oct., 1921.)—According to Geiger and Marsden [see Abs. 79 and 1355 (1911)] actinium emanation, which is in itself an α-ray product, gives rise to another α-ray product, actinium A, having a period of 0·0020 second. Thus, under ordinary conditions, the atom of the emanation will suffer two disintegrations *in situ* in exceedingly rapid succession.

By utilising the well-known condensation method of C. T. R. Wilson, the authors have been successful in obtaining photographic records of α-ray tracks which illustrate the essential features of the above process. Actinium emanation is mixed with the air in the Wilson cloud apparatus when the expansion takes place. If an atom of the emanation eventually undergoes two successive α-disintegrations in the effective interval of the expansion, both of the escaped α-particles would leave visible tracks having their heads at a common point or in the immediate neighbourhood, thus forming a pair of tracks.

Photographic records are reproduced in illustration of this effect, most of the α-ray tracks occurring in pairs in accordance with expectation. Attempts have been made to find, if any, the most probable angle included in each pair of tracks, but as yet the experimental results are insufficient to enable definite conclusions to be drawn. [Errata, *ibid.* Nov., 1921.] A. B. W.

147. *The "Drop" Emanationscope; a Method for the Rapid Determination of the Emanation Content of Radio-Active Water.* **P. Ludewig.** (Phys. Zeits. 22. pp. 298–302, May 15, 1921.)—A description is given of an entirely novel method of determination of the emanation content of water samples. The ionisation-chamber contains a number of sloping platforms arranged in series, down which the water sample is allowed to drip in succession. In this manner a large area of water, of very small thickness is exposed in the ionisation chamber. For details of the method the original paper should be consulted. A. B. W.

148. *Branched α-Ray Tracks; Preliminary Note.* **T. Shimizu.** (Roy. Soc. Proc. 99. pp. 432–435, Aug. 2, 1921.)—Employing the reciprocating expansion apparatus previously mentioned [see Abs. 208 (1922)], the author has obtained "stereoscopic" photographs of a large number of α-ray tracks. Of these photographs, a very small fraction show clear indications of branching tracks with "spurs"—these tracks being due, according to Rutherford's theory, to close nuclear collisions of the α-particles with the gaseous atoms in the expansion chamber. On Rutherford's theory only one in 100,000 of the α-rays from RaC comes into such close collision, but the author's preliminary experiments indicate that the proportion is much greater than this, namely, one in a few hundred. Excellent reproductions are given of the photographs of an α-ray track viewed from two positions at right angles to each other: the reproductions show very clearly the "branching" and "spurring" due to the close collision.

The paper contains a detailed description of the experimental method for taking simultaneous photographs from positions such that the ionisation tracks are viewed from mutually perpendicular directions. A. B. W.

HEAT.

149. *Specific Heat of Sulphuric and Nitric Acids and of their Mixtures.* **P. Pascal** and **Garnier.** (Soc. Chim. Bull. [iv] 27–28. pp. 8–18, Jan. 5, 1920.)—The calorimeter is a glass cylinder, 8 cm. diameter, 10 cm. deep, silvered outside, standing in a Dewar vessel; it is heated by platinum resistance. As the dilution with water of the sulphuric acid increases from 0 to 90 per cent. the specific heat goes up from 0·335 to 0·916; the specific heat of nitric acid with 98·15 % of HNO_3 is 0·475, that of the 10 per cent. acid 0·900—all values reduced to 20°. A mixture of 22 % sulphuric acid, 77 nitric, and 0·7 NO_2 has a specific heat of 0·430; when the proportions are 90, 9·9, 0·1, the heat is 0·3444. The results are set out in tables and in graphs. H. B.

150. *Heat of Vaporisation of Hydrogen.* **W. H. Keesom.** (Zeits. Sauerstoff u. Stickstoff Ind. 11. p. 83, Nov. 8, 1919. Chem. Zentrbl. i. p. 147, 1920.)—According to Dewar the heat of vaporisation of hydrogen is 123 kg. cals.; the author from various theoretical considerations suggests values between 108·5 and 113·2 kg. cals. H. B.

151. *Melting-Points of Pure Metals and Elements.* **W. Guertler** and **M. Pirani.** (Zeits. Metallk. 11. pp. 1–7, June, 1919. Chem. Zentrbl. iii. pp. 910–911, 1919.)—The melting-points of 66 elements are: Ag 961°, Al 658°, As 850° (?), Au 1063°, B 2400°, Ba 850°, Gl 1300° (?), Bi 270°, C > 3600°, Ca 809°, Cd 321°, Ce 700°, Cl − 101·5°, Co 1490°, Cr 1520°, Cs 26°, Cu 1084°, Fe 1530°, F − 223°, Ga 30°, Ge 958°, H — 259°, Hg − 39·7°, I 113·5°, In 155°, Ir 2350°, K 62·4°, La 810°, Li 186°, Mg 651, Mn 1210°, Mo 2410° (?), N − 210°, Na 97·5°, Nb or Cb 1700° (?), Nd 840°, Ni 1452°, O − 218°, Os 2700° (?), P 930°, Pb 327·4°, Pd 1545°, Pr 940° (?), Pt 1760, Ra 700°, Rb 38°, Rh 1960°, Ru 2450° (?), S 119·2°, Sa 1300, Sb 630°, Se 217°, Si 1420°, Sr < Ca < Ba; Sn 232°, Ta 2800°, Te 450°, Th > Pt 1800°, Ti 2000° (?), Tl 301°, U > 1850°, V 1800°, W 3030°, Y 1490°, Zn 419·4°, Zr 1700° (?). The paper also illustrates the dependence of the melting-point on the position in the periodic table. H. B.

152. *Free Energy and the Hypothesis of Nernst.* **A. Boutaric.** (Le Radium, 11. pp. 257–262, July–Aug., 298–305, Sept.–Oct., and 348–356, Nov.-Dec., 1919.)—Papers on energy relations generally start from the Helmholtz-Gibbs equation: $A - U = T \, . \, (\partial A/\partial T)$, where A is the free energy and A − U the bound energy. But these terms are not understood in the same sense by various writers, nor even consistently used by the same writers, comprising Nernst. The author directs attention to this looseness of the terminology, and discusses various applications of Nernst's theorem and of the limits of its reliability. H. B.

153. *Differential Thermometer.* **A. W. C. Menzies.** (Nat. Acad. Sci., Proc. 7. pp. 81–83, March, 1921. Am. Chem. Soc., J. 43. pp. 2309–2314, Nov., 1921.)—A well-known differential thermoscope for detecting a difference between the temperatures existing simultaneously at different points consists of two glass bulbs containing air and communicating one with the other through a U-tube partly filled with oil, the change of level in which indicates difference of temperature by responding to change of gas pressure in the bulbs. When this instrument is developed into a differential thermometer, various disadvantages become apparent, but the author finds that these may be avoided if the use of permanent gas in the bulbs is abandoned. As manometric liquid the oil is replaced by a liquid whose change of vapour pressure per degree in the range of temperature where the differential measurements are to be made is such as to cause differences of vapour pressure in the two bulbs of the thermometer that will register themselves by adequate differences of level in the manometer. For many purposes water is a suitable filling liquid, but the sensitiveness in any particular range of temperature may be given widely different values according to the rate of change of vapour pressure and the density of the liquid selected.

The ordinary Beckmann mercurial thermometer is restricted to temperatures lying between − 39° and + 250°. Although this is a much wider range than can be conveniently covered by the use of any single liquid in the type now described, yet the simplicity of construction of the latter renders possible such a wide choice of filling liquids that a greatly increased range is available for both lower and higher temperatures. T. H. P.

154. *Application of a Differential Thermometer in Ebullioscopy.* **A. W. C. Menzies** and **S. L. Wright.** (Nat. Acad. Sci., Proc. 7. pp. 77–80, March, 1921. Am. Chem. Soc., J. 43. pp. 2314–2323, Nov., 1921.)—The author applies his differential thermometer [see preceding Abs.] to ebullioscopic measurements, use being also made, as proposed by Cottrell, of a lift-pump to pump the solution over the bulb of the thermometer, which need not be submerged in the solution but is situated in the vapour phase above the liquid. The apparatus, which is entirely free from all corks, ground glass joints or stoppers, consists of a boiling tube, the narrowed upper portion of which serves as condenser tube. A glass cylinder, open above and below and of slightly less diameter than the boiling tube, is placed concentrically within the latter and acts as a double jacket. Within this is supported the differential thermometer, on the lower bulb of which the pump hangs loosely; the absence of rigid connection diminishes breakage and adds flexibility. The boiling tube is heated by a common Bunsen burner with a low flame protected by the usual draught shield. When boiling begins, portions of the liquid in the bulb are carried by the vapour in fragments up the pump and discharged to form a thin film over the lower bulb of the thermometer, which thus attains the temperature at which this solution is in equilibrium with the vapour. The upper bulb acquires the temperature of the pure boiling solvent, the thermometer registering the difference between these two temperatures. Equilibrium is reached so rapidly that fresh additions of solute may be made as fast as they can be weighed. Good results are obtained even in a room not free from draughts. To minimise the error caused by the absence of part of the solvent from the solution as condensate on the walls or as vapour, the boiling tube is constricted above the lower bulb and graduated on the cylindrical neck so formed; the actual volume of the liquid is read an instant after the ebullition ceases.

A simple water-filled differential thermometer suffices for the range of temperature between the boiling-points of water and ether and thus serves for various other solvents. No "setting" of the thermometer for the use of different solvents is required. T. H. P.

155. *Expansion of Aluminium-Zinc Alloys.* **A. Schulze.** (Phys. Zeits. 22. pp. 403–406, July 15, 1921. From the Physikal.-Techn. Reichsanstalt).—A table is given showing the expansion of 9 samples containing varying percentages of Zn and Al for the temperature range 20°–400° C. by stages.

The pure Al shows a smaller expansion than that found by Scheel, the difference amounting to 3 % at 400°. On the other hand the values for expansion of zinc are extraordinarily high. For temperatures of 20° to 100° the mean coefficient of expansion is equal to $\Delta l/l.\Delta t + 36{\cdot}4 \times 10^{-6}$. For temperatures of 20° to 300° the thermal expansion of zinc is well shown by a quadratic interpolation formula. This is also the case for pure Al and for alloys with 87·5 and 75 % Al in the temperature region 20° to 400°. The course of the expansion curve is more complicated for the other alloys examined. While with rising and falling temperatures the same values for thermal expansion were observed with the alloy containing 75 % Al, the measurements obtained with an alloy containing 62·5 % Al from 250° to 280° were higher with falling than with rising temperatures. This peculiar behaviour in the expansion points to a chemical change. Curves are given which show this hysteresis effect with the following alloys: 62·5 % Al, 37·5 % Zn; 25 % Al, 75 % Zn; 12·5 % Al, 87·5 % Zn. A. E. G.

156. *Latent Heats of Fusion of Nickel and Monel Metal.* **W. P. White.** (Chem. and Met. Eng. 25. pp. 17–21, July 6, 1921.)—Specimens of nickel and "Monel" metal in the form of cylinders about 27 gm. in weight were heated in an electric furnace and dropped into a water calorimeter. The metals were enclosed in a silica glass container, which was exhausted and sealed before being put into the furnace. Separate experiments were performed in order to obtain the heat given out by the silica tubes alone. The correction obtained from these experiments also eliminated the loss of heat in dropping from the furnace into the calorimeter. Special precautions were taken in measuring the true temperature of the furnace, a carefully calibrated Pt-Rh couple being used. Another differential couple gave the difference between the temperature of the main thermo-couple and that of the metal itself. The dropping of the specimens was performed by a mechanical arrangement. A swinging shield between the furnace and the calorimeter was swung aside to open the path to the calorimeter, and immediately closed to prevent radiation from furnace to calorimeter. The calorimetric temperature was measured by a thermo-couple reading to 0·0003 deg. The latent heats are found as the difference of total heat of fused metal and total heat of solid metal at the same temperature. The results obtained are 73 cals. per gm. for nickel and 68 for Monel metal. The value for Ni, which differs very appreciably from the 56 given by Wüst [see Abs. 115 (1920)], was confirmed by a direct pouring method which agreed within about 2 %. A brief critical review of Wüst's method is included in the paper. T. B.

157. *Contribution to the Proof of Planck's Radiation Formula.* **H. Rubens** and **G. Michel.** (Preuss. Akad. Wiss. Berlin, Ber. 38. pp. 590–

610, 1921. Phys. Zeits. 22. pp. 569–577; Disc. 577, Oct. 1 and 15, 1921. Paper read before the Deut. Physikertag., Jena, Sept., 1921.)—The measurements recorded arose out of the critical examination by W. Nernst and T. Wulf [Abs. 1414 (1919)] of the material then available on radiation from a black body. These physicists assumed in the proof of Planck's formula that: (1) Wien's displacement law is rigorously true; (2) for large values of $x = c/\lambda\tau$ Wien's radiation formula holds; (3) for small x, i.e. large wave-length and high temperature the Rayleigh–Jeans radiation formula agrees with observations. The value of the radiation constant was assumed to be 14,300. Nernst and Wulf concluded, however, that Planck's formula was not rigorously true in the region between those covered by Wien's law and the Rayleigh–Jeans law, but that a correction (maximum 7·2 % for $x = 2\cdot5$) was necessary. This correction decreased rapidly for smaller values of x, and slowly for larger values, as shown by a curve given in the paper.

It cannot be doubted that the assumptions of Nernst and Wulf are well founded. On the other hand the results of experiments which cover the above-mentioned region are not sufficient, and are 20 years old, and great improvements in instruments and methods have been made in that interval. The authors, therefore, have endeavoured to obtain better and more up-to-date results in order to test the validity of Planck's formula in the region referred to. They have employed the method of "isochromatics" which has many advantages. The black bodies used, four in number, allowed a variation in temperature of radiation from that of liquid air to 1400° C., and in a few cases to that of the melting-point of palladium. Isochromatics for wave-lengths 4, 5, 7, 9, 12, 16, 22, and 52μ were investigated. The tables of results obtained show that Planck's formula agrees with the results of observation to ± 1 %. The authors obtain for the melting-point of Pd a value which differs by only 2 to 3 deg. from that obtained by the Reichsanstalt. T. B.

158. *The Cohesion Forces in the Theory of van der Waals.* **W. H. Keesom.** (K. Akad. Amsterdam, Proc. 23. 6. pp. 943–948, 1921. Phys. Zeits. 22. pp. 129–141, March 1, 1921.)—Debye has recently shown in an important paper on the cohesion forces in the theory of van der Waals, that these may be explained in this way, that one molecule in the field of neighbouring molecules obtains a dipole moment, and that because of this dipole moment it is attracted by the inducing molecule. Debye considered especially those gases the molecules of which possess no spontaneous dipole moment. In the calculation he assumed that the field of the molecules could be treated to first approximation as that of a tetrapole. Evidently neighbouring molecules will influence their mutual direction in such a way that the cases of attraction are more frequent than those of repulsion. In a preliminary orientating calculation, the mean mutual attraction of the molecules due to their own tetrapole moment was neglected. In fact, this will be allowed, as has already been remarked by Debye for sufficiently high temperatures: for this mean attraction vanishes when the heat movement hinders the directing influences of the molecules mutually. The author has shown [see Abs. 907 (1916)] that the molecular attraction in hydrogen, at least as far as to the second virial coefficient, may be explained by the circumstance that those molecules possess a tetrapole moment, while a contribution to the attraction due to the mobility of the electrons in the molecules was neglected. In fact, Debye remarks rightly that, in the calculation of the molecular attraction, attention must be paid to the attraction of the molecules mutually because of their tetrapole moments, as well as to that especially treated by Debye and due to the polarisation of the molecules in an electric field.

This paper discusses principally the influence of the molecular attraction on the equation of state, restriction being made to the second virial coefficient. The comparative influence on the second virial coefficient of the above-mentioned attractions is studied at the temperatures for which the measurements on the equation of state were made, and it is shown that the molecular attraction in B is principally due to the spontaneous tetrapole moments of the molecules. Section 2 of the paper deals with preliminary orientation; section 3, with the second virial coefficient for spherical polarisable tetrapolar molecules. For gases such as hydrogen, oxygen, and nitrogen, it is established that the cohesion forces introduced by van der Waals into the equation of state are ascribed principally to the forces exerted by the molecules on each other because of their tetrapole moments. H. H. Ho.

159. *The Second Virial Coefficient of the Rare Gases.* **F. Zwicky.** (Phys. Zeits. 22. pp. 449–457, Aug. 15, 1921.)—In this paper the equation of state for helium and argon is derived on the basis of the Debye theory for the mutual attraction of polarisable molecules. A force-law is employed which only depends on the distance apart of two molecules, and not on their particular orientation. The latter disappears when, according to Keesom [see preceding Abs.], the second virial coefficients are taken as the chief determining effect. The possibility is afforded of an experimental decision between the conceptions of Debye and Keesom. For the van der Waals cohesion forces in the rare gases Debye has only assumed the attraction of the molecules by mutual polarisation and has discovered many facts which give a qualitative support to his theory. The proof that these facts also afford quantitative support is now brought forward. The further fact that for the rare gases quanta effects play no essential part at very low temperatures in the equation of state, is taken in conjunction with the spherical symmetry of the atom and appreciably simplifies the calculation. Section 1 derives the equation of state for argon, and section 2 that for helium. [The paper is mathematical throughout.] H. H. Ho.

160. *The Accuracy of Condition Observations and the Calculation of the Transition Point of the Throttle Phenomenon.* **K. Schreber.** (Phys. Zeits. 22. pp. 335–336, June 1, 1921.)—Amagat's diagram of $pv = f(p)$ was a great advance in the representation of observations concerning state (or condition). For a simple gas, $f(p)$ must be a straight line parallel to the p-axis, and deviations therefrom are easy to recognise. For different temperatures these lines lie so far apart as to be difficult of comparison. When pv is divided by the temperature, $pv/T = P$, then for a simple gas P is independent of temperature and equals R. When P is put equal to $f(p)$, then the lines occur sufficiently near for deviations due to temperature influence to be compared. If this deviation, P − R, be divided by p, then in $(P - R)/p = y$, is an expression which admits comparison of deviations shown by actual gases in a much more convenient fashion than heretofore. The author has applied this method to Amagat's observations on air, and shows how a criterion is afforded with respect to the accuracy of these observations. It becomes evident that Amagat's observations are not accurate enough for the evaluation of the transition point of the throttle effect. The author opines that no probability exists that Amagat's observations with other substances are any more accurate than those on air. The argument is illustrated diagrammatically. H. H. Ho.

161. *On Positively Coherent, Negatively Coherent, and Natural Radiation.* **E. Kretschmann.** (Zeits. f. Physik, 5. 1. pp. 77–90, 1921.)—This paper deals with the idea and hypothesis of natural radiation from a simplified mathematical and physical standpoint. The continuous emitting and absorbing Planck oscillator serves as an ideal intensity measure of the radiation, while the Fourier integrals are used in place of the customary analysis, since they can be expanded to the extent necessary for intensity determination. The advantage is thus obtained of connecting the Fourier and the spectral analysis of radiation [see Abs. 1795 (1921)]. Section I deals with coherent and incoherent oscillations. Section II considers the oscillations of a Planck oscillator in any given radiation field, and section III the energy balance of the oscillator. Section IV investigates the conception of natural radiation and its origin. Natural radiation appears to be incoherent and is not only to be regarded, as hitherto, as a mathematical form of radiation, but one also realisable from the nature of thermal equilibrium. H. H. Ho.

162. *The Entropy of Electron Gas.* **R. C. Tolman.** (Am. Chem. Soc., J. 43. pp. 1592–1601, July, 1921.)—Under certain conditions electrons may be treated as the atoms of a chemical substance. Laue has investigated the conditions under which the gas will obey the perfect gas laws [Abs. 1421 (1919)], while H. A. Wilson and others have applied thermodynamical reasoning to the behaviour of the gas. The restrictions which are necessary in order that the gas laws may apply are of the same nature though more stringent than those for the more familiar monatomic gases. Electron gas is apparently a gas which is *plus que parfait* at all temperatures and pressures, while most gases are *moins que parfait.* The entropy of the gas is found to be $S = 5/2R \log T - R \log p + 3/2R \log M + S_1$, where M is the molecular weight of the electron ($5{\cdot}44 \times 10^{-4}$ gm.), and S_1 has the same value for all monatomic gases. The entropy of electron gas as calculated from this equation actually agrees with the entropy of the electron gas in equilibrium with W, Ta, and Mo filaments at 2000° abs. as calculated from the heat known to be absorbed when electrons are emitted from the hot filaments. The values obtained for S are as follows: (*a*) Calculated from the equation: W, 53·3; Ta, 52·3; Mo, 51·0; (*b*) Calculated from the heat of vaporisation: W, 53·6; Ta, 54·0; Mo, 54·9. T. B.

163. *Thermal Ionisation of Metallic Vapours.* **R. C. Tolman.** (Am. Chem. Soc., J. 43. pp. 1630–1632, July, 1921.)—The equation $S = 5/2R \log T - R \log p + 3/2R \log M + S_1$ [see preceding Abs.] may be employed in predicting the thermal ionisation of metallic vapours. If Kp is the equilibrium constant, using partial pressures expressed in atmos., E the ionisation potential in volts, and T the temperature in degrees abs., then it is shown that $\log_{10} Kp = -5040E/T + 2\cdot5 \log_{10} T - 6\cdot69$. This equation may be used for finding the degree of ionisation of metallic vapours in the electric arc or the sun's atmosphere. It is found, for example, with certain assumptions that the partial pressure of calcium ion or of electron gas in the sun's atmosphere is 0·07 atmo., corresponding to 1·7 % ionisation. T. B.

164. *The Total Heat of Liquid Carbon Dioxide; Assumption of Constant C_v Unwarranted.* **C. F. Jenkin** and **D. N. Shorthose.** (Roy. Soc., Proc. 99. pp. 352–361, July 1, 1921.)—Total heats of CO_2 at pressures and temperatures above the critical point have been measured, the method employed being the same, with a few modifications, as that described in a previous paper [see Abs. 1432 (1915)]. The results there given for high temperatures and pressures, however, are based on an unverified assumption, namely, that the specific heat of CO_2 at constant volume is constant and equal to 0·214. The present direct measurements were considered advisable to test the accuracy of this assumption.

The liquid CO_2 is contained in a "weighing flask," hung on a steelyard lever, which falls and rings a bell as each 2 lbs. of CO_2 leaves the flask, 20 lbs. being usually employed in each experiment. The liquid is pumped at a uniform rate round a circuit by a motor-driven condensing pump, expanding through two throttle valves to a pressure of about 200 lbs. per sq. in. It is compressed adiabatically to the desired pressure, say, 1800 lbs., cooled to a constant temperature, about 12° C., and passed through an electrical calorimeter of special design, where it is heated to the required temperature. The temperature of the CO_2 is accurately measured by two carefully calibrated thermo-junctions of eureka-copper before and after heating in the calorimeter, and the electrical power supplied to the calorimeter to heat the CO_2 was measured by a Siemens precision wattmeter. After leaving the calorimeter, where the pressure is controlled by a third valve and measured by a gauge, the liquid is throttled through another valve and cooled in a condensing coil to the starting point. The whole cycle of operations is exhibited on an I, ϕ chart, from which the total heat at any pressure and temperature can be read. Results are given for pressures 900 to 1800 lbs. per sq. in. and between temperatures 12° and 100° C., both in tabular and graphical form.

The chart given in the former paper referred to is found to give results at the higher temperatures and pressures slightly too low, and it appears that the assumption of a constant specific heat C_v is unwarranted. This point is being further investigated. T. B.

165. *Some Mechanical Considerations and their Critical Importance for Thermodynamics.* **J. Geissler.** (Zeits. Elektrochem. 27. pp. 209–216, May, 1921).—The present paper attempts to give a survey of the thermodynamic conception of energy, and also to derive the correct scientific nomenclature for the ideas described. Previous statements with respect to the energy conception have been lacking in precision, the Nernst definition of maximum work and that of free energy by Helmholtz being expressions for the idea of potential work. The thermodynamic quantity $T \,.\, dA/dT$ is a kinetic potential. The indefiniteness which exists is found to be largely due to an aversion for the expression "potential." The second law of thermodynamics has the following sense: "Changes of latent heat and of kinetic potential are identical." A technical model has been devised which includes the second law of thermodynamics as a special case. An energy scheme shows that the total energy can be regarded as the sum of the potential and kinetic energies, and also as the difference of potential work and stock of energy. Further, the kinetic potential is either equal to the sum of the kinetic energy and stock of energy, or else to the difference of potential work and potential energy. The potential energy cannot be evaluated thermo-dynamically. H. H. Ho.

166. *The Critical Energy Increment and Trouton's Rule.* **E. K. Rideal.** (Phil. Mag. 42. pp. 156–163, July, 1921.)—The critical energy increment for a molecular species is shown to be an average value of the energy necessary to cause a gm. molecule to become reactive. Experiments have shown that the combination between two given substances may sometimes take place in different ways, entailing different increments of critical energy, for example the decomposition of HI and the formation of ozone [see Abs. 1191 (1920)]. In the latter case it was noted that the activation of the oxygen molecules could take place in two stages, one in the infra-red, the other in the ultra-violet. In any system some of the molecules are inactive, and require a critical energy increment $E = Nh\nu_{u.v}$ (h being Planck's constant, and $\nu_{u.v}$ the vibration frequency in the ultra-violet). Molecules already activated to the infra-red stage would require energy only $E = Nh(\nu_{u.v.} - \nu_{i.r.})$. The various degrees of activation of a molecular species can be calculated from the bands or lines in the absorption or emission spectrum.

Trouton's rule states that the molecular latent heat of vaporisation divided by the boiling-point is constant, and equal to 22. On the quantum hypothesis it is pointed out by Perrin that this means the frequency of the radiation which determines the boiling-point is proportional to the boiling-point. Trouton's rule holds more correctly in terms of the critical temperature T_c, thus $L/T_c = 2/3 \times 22 = 14 \cdot 66$. Now Wien's displacement law gives $\lambda_{max.} \,.\, T_c = C$, where $\lambda_{max.}$ is the wavelength corresponding to the energy maximum, or $T_c/\nu_v =$ constant, where ν_v is the frequency. Also the latent heat of evaporation of a non-associated liquid is $L = Nh\nu$ or $L/T_c =$ constant.

Proceeding on these lines, and inserting known values for the constants, the equation $L = 9 \cdot 866 T_c$ is obtained. Values of L for about 20 substances are calculated from this equation. They are then compared with those obtained from Trouton's rule (see above), and with values given by van der Waals' equation, $L = 27/64 \,.\, (R^2T_c^2)/p_c b$. The divergence between the calculated values and those given by experiment is probably to be ascribed to association. It is deduced that the extra energy which is supplied during evaporation is that necessary for the decomposition of the associated molecules into single ones. T. B.

167. *A New Equation of State for Gases based on Knowledge of the Internal Pressures.* **A. Leduc.** (Comptes Rendus, 172. pp. 1167–1170, May 9, 1921.)—The equation of the type of van der Waals', modified by the introduction of the factor $1/T$ in the internal pressure, admits, like the original equation, of the idea of corresponding states and gives rise to the reduced equation $(P + 3/TV^2)(3V - 1) = 8T$. This equation fails for large volumes since the expression PV/T should tend towards 8/3, and the present author now shows this limit to be very different. From the author's experiments on densities and compressibilities of gases, and also from those of Chappius on dilatation, the expression M*pv*/T is found to tend towards the limit for all gases of R = 8319 × 10^4 c.g.s. (if $M_{\text{oxygen}} = 32$). The agreement of the two limits demands that $MP_cV_c/T_c = \frac{3}{8} \times 8319 \times 10^4 = 312 \times 10^5$. The calculation of this expression from data relating to gases which obey the law of corresponding states at pressures of atmospheric order (normal series), shows that it varies in a non-systematic manner between 204 and 249 × 10^5, with a majority of values near to the average 229 × 10^5. In the reduced equation it is therefore necessary to replace V by the experimental value $D_c = MP_c/312 \times 10^5T_c$. The author next shows that the standard reduced formula for the internal pressure, $TdP/dT - P = 6/TV^2$, is inapplicable. The data employed are for SO_2 and CO_2 at temperatures varying between 0° and 1000°, and at pressures from 0·5 to 2 atmos. The reduced internal pressure is found to be $ka^{1/T}/V^2$, and the above reduced expression becomes $TdP/dT - P = ka^{1/T}/V^2$, which gives for the reduced equation of state between the specified limits, $[P + T(4^{1/T} - 1)/V^2](3V - 1) = 8T$. H. H. Ho.

168. *Surfaces of Free Energy: Stability Limits: a Geometrical Discussion.* **M. Brillouin.** (Ann. de Physique, 16. pp. 34–67, July–Aug., 1921.)—This paper commences at Chapter IV, the previous chapters having been dealt with in Abs. 1360 (1920). The complicated character of the equations of stability previously obtained for extremely simple forms of free energy, show that it would be futile to pursue an algebraic discussion for more general cases. Accordingly conditions of stability have to be treated geometrically so as to render as intuitive as possible the relation between stability and the form of the free energy surfaces. Section A deals with the geometrical stability conditions under given total strains. It is found that for stability, each surface of available energy must be convex on the side where this energy increases. There are two kinds of stability—the one dependent uniquely on the form of the surfaces of available energy, which gives the conditions of lateral stability; the other dependent only on the law of increase of available energy along each trajectory, and in no wise on the form of the surfaces about this line, which gives the condition of longitudinal stability. The latter condition has alone occupied investigators up to the present time. The almost rigid conservation of Hooke's law so far as the rupture of fragile bodies or, up to the appearance of localised deformations, of malleable metals, shows that lateral stability disappears before longitudinal stability commences to diminish. The form of the energy surfaces is therefore of the utmost importance for the definition of stability. Practically the loss of lateral stability is produced at the moment when real asymptotic lines appear on the surfaces of available energy. The asymptotic direction defines the deformation, which ceases to be determined by the reversible elastic tensor. Other actions which are either non-existent or of little importance during stable elastic deformations become preponderant in the new state. The author discusses at great length the experimental study of the conditions of lateral stability. Section B deals with stability under actual given tensions. The paper is mathematical throughout. The discussion of longitudinal stability under elastic tensions per unit of actual surface is always more complicated and less intuitive than under total tensions per unit of initial surface. H. H. Ho.

169. *Einstein Light-Quanta and Spacial Structure of Radiation.* **M. Wolfke.** (Phys. Zeits. 22. pp. 375–379, July 1, 1921.)—Notwithstanding the great development of the quantum theory during the last decade, the principal question concerning the nature of the quanta still remains unanswered. It is known that the solution is to be sought for in a discontinuity in nature processes, especially in the molecular and intra-molecular regions, but an advance has not been made beyond the acceptance of this standpoint. In the present paper, the Einstein light-quanta and the spacial structure of radiation are investigated. Einstein postulated discontinuity [see Abs. 654 (1917)] not only for the interaction between matter and the radiation field, but he assumed that in the radiation field itself the energy is connected with discrete centres, the so-called light-quanta. Einstein's basis for the latter conception has withstood all the obligations of classical optics. Section 1 of the paper deals with the radiation portion of hollow space radiation. It is shown that dark radiation consists of a series of radiation parts thermodynamically independent of each other, and connected according to the mode of the Wien radiation formula. Section 2 considers the physical significance of the radiation parts and from the standpoint of the Einstein light-quanta, these are conceived as light molecules $ih\nu$ spacially independent of each other. The continuous space radiation at high radiation-densities may thus be resolved on Einstein's hypothesis into discrete light-molecules, which become less complex with decreasing radiation density, and finally at very small densities are dissociated into discrete light-atoms. H. H. Ho.

170. *Vapour-Pressure Regularities.* IV *and* V. **W. Herz.** (Zeits. Elektrochem. 27. pp. 125–126, March 1, 1921.)—The author shows that the critical temperature may in van der Waals' formula conveniently be replaced by the expansion coefficient. He further refers to the vapour-pressure formula of Cederberg (Thermodynamic Calculation of Chemical Affinities, Upsala, 1916) which Nernst found useful in his new heat theorem of 1918. In homologous series of organic compounds (pentane to octane, methyl alcohol to propyl alcohol, etc.) the Cederberg constant (approximately 6) becomes larger as the atomic weight increases. H. B.

171. *Critical Observations on the Traditional Representation of Thermodynamics.* **M. Born.** (Phys. Zeits. 22. pp. 218–224, April 1; 249–254, April 15, and pp. 282–286, May 1, 1921.)—This is a theoretical discussion in which the author points out the importance of Carathéodory's work (Math. Ann. 61. p. 355, 1909) which has passed almost unnoticed by physicists, although it achieves the logical ideal in thermodynamics, namely, the separation of the physical content from the mathematical representation. L. H. W.

SOUND.

172. *Acoustical Galvanometer for Small Alternating Currents.* **F. R. Watson** and **L. B. Ham.** (Phys. Rev. 18. pp. 178–184, Sept., 1921.)—By sending the current through a telephone receiver, magnifying the emitted sound by means of a double resonator, and measuring the intensity of the sound by means of a Rayleigh disc hung in the tube connecting the resonating chambers, a measure of the alternating current is obtained in terms of the rotation of the disc. The variation of the sensitivity with frequency was investigated with the help of a hot-wire ammeter. For the particular instrument studied maxima were found at frequencies of the resonator and telephone diaphragm. The sensitivity at the frequency of 510 per sec. is given as 1 mm. deflection on a scale 1 m. distant for a current of about $5 \cdot 7 \times 10^{-8}$ amp. [This value appears to have been deduced on the basis of a linear law from the graph in the paper; the amended value would be of the order $7 \cdot 5 \times 10^{-7}$.] The author believes a much more sensitive instrument could be made by using sharper resonance and a more delicate quartz suspension. Measurements of the intensity of pure telephone sounds are possible with this instrument. E. H. B.

173. *Partial Tones of Consonants and their Critical Pitches for Speech Recognition.* **C. Stumpf.** (Preuss. Akad. Wiss. Berlin, Ber. 39. pp. 636–640, 1921.)—By experimental investigations the author finds the following pitches for the corresponding consonants.

Voiceless Consonants.	Pitches.	Voiceless Consonants.	Pitches.
R(lingual)........	a^2–e^3	Ng, M, N	b^3–f^4
K (P, T)	des^3–es^4	L	c^4–f^4
Ch (guttural)	d^3–a^3	S..............	des^4–c^5
H	es^3–des^4	F	des^4–des^5
Sch	f^3–es^4	Ch (palatal)	es^4–des^5

E. H. B.

174. *Gaseous Acoustic Oscillators.* **W. Hahnemann** and **H. Hecht.** (Phys. Zeits. 22. pp. 353–360, June 15, 1921.)—In a previous paper [*ibid.* 21. p. 187 (1920)] the authors considered the mechanical oscillations of two elasticity-free masses with an elastic massless connection. The present paper deals with the acoustic oscillations in gas-filled chambers connected together. The assumption is made that the chambers are small compared with the wave-length of the respective fundamental frequencies, so that only quasi-stationary phenomena have to be dealt with. Formulæ are deduced for the natural frequency, the damping due to conduction and radiation, and for the coupling, for two chambers with a connecting opening. As a special case the open or Helmholtz resonator is considered, and formulæ are deduced for its natural frequency and radiation damping. Experimental data relative to connected chambers and to Helmholtz resonators are given; these confirm the theoretical results obtained. A. W.

ELECTRICITY AND MAGNETISM.

THEORY, ELECTROSTATICS, AND ATMOSPHERIC ELECTRICITY.

175. *Effects of Electric Force on a Permanent Electret.* **M. Eguchi.** (Phys. Math. Soc. Japan, Proc. 3. pp. 110–116, Oct., 1921.)—The effect of the application of an electric force upon the intensity of polarisation of an electret is investigated in the case of two polarised discs, whose senses of polarisation are known in regard to the direction of the field applied in their preparation. For one of the discs (equal parts Carnauba wax and resin) a complete history of experimental treatment and observations, including surface density measurements, is given in tabular form and relates to a total period of 87 days. The results from both discs are summarised in graphs. It is concluded that by the application of electric force, positive or negative, electricity enters the material only to a very small depth from the surface while the permanent polarisation of the electret remains almost unaffected. A. B. C. L.

176. *On the Behaviour of Electricity at Rest in the Non-Static Gravitational Field (Variable or Stationary).* **W. Alexandrow.** (Ann. d. Physik, 65. 8. pp. 675–696, Oct. 13, 1921.)—The basic idea of the relativity theory shows that a moving electron with permanent metrical relations can be replaced by a static electron in a variable gravitational field. A static electron must, in general, emit radiation under the influence of a gravitational wave. The object of the present paper is to confirm this behaviour from the standpoint of the field equations. It is found, in general, that an electrostatic charge (the behaviour of electricity at rest) in the weak variable gravitational field can be regarded as electrodynamic in a space free from gravitation. The gravitational field in the field of static electricity produces current and induction effects, *i.e.* in the non-static gravitational field, the static electricity produces in addition to electrostatic effects a stationary magnetic field or it "radiates." Section 1 deals with the further consequences of the analogy between the weak gravitational and electromagnetic fields which are derived by approximate integration of the gravitational equations [see Abs. 907 (1918)]. An analogy is derived for gravitational waves with the Hertz solution of the problem of a point emitter. Section 2 deals with the electromagnetic field of static electricity in the weak, non-static, gravitational field. Section 3 considers the electromagnetic field of static electricity in the stationary and so-called special (Einstein) gravitational fields. Here the example of a true stationary gravitational field is taken from the field calculated by Lense and Thirring from the rotation of a spherical mass-nucleus. The paper is mathematical throughout. An appendix refers to agreement with similar work by Mie. H. H. Ho.

177. *Density and Charge of Selenium Particles.* **R. Bär** and **F. Luchsinger.** (Phys. Zeits. 22. pp. 225–230, April 15, 1921.)—The Ehrenhaft-Millikan method for determining the size and charge of microscopic and submicroscopic particles depends on the assumptions (1) that for the motion of such particles under an external force the Stokes-Cunningham law holds good, and (2) that the particles have a spherical shape, and have the same density as that of the material from which they are driven out. Experiments now described show that the Stokes-Cunningham law is not valid for extremely small particles, and, further, that selenium particles may differ appreciably in density. However, it may happen that though errors are introduced by the above assumptions (1) and (2), they may balance out, so that it cannot be stated with certainty that Ehrenhaft's results are wrong. Research is in progress with the object of finding the resistance law to replace the Stokes-Cunningham law for extremely small particles. A. W.

178. *Revision of Electromagnetic Laws.* **C. Hering.** (Frank. Inst., J. 192. pp. 599–622, Nov., 1921.)—A collection of various experiments is given in which the results are claimed to be contrary to or different from those required by the usual forms of these laws. Accepted as they are usually stated, these laws are said to have sometimes led to failures due to errors in the way they are stated, and they may have closed the doors to fields of development which may be possible. It is shown that the flux in a closed circuit may be altered without inducing any e.m.f.; experiments are described in which there are decided movements of conductors in the directions of their axes, the forces for which have been strenuously denied in the past. Suggestions are made how these laws might be revised to meet these new experiments. It is claimed that a certain generally accepted fundamental law in mechanics should apply to electric circuits also; this would explain the real seat or origin of these forces and would justify the existence of all observed forces, including some heretofore denied. It is claimed that according to this law any movements of a conductor will tend to take place, regardless of any particular direction, which will induce a counter e.m.f., whereby the potential energy of a system is reduced. Among the developments of recent years in this direction, the so-called pinch effect, the stretch effect, and the corner effect, are described and discussed. AUTHOR.

179. *The Waterfall Theory of Thunderstorms.* **P. Lenard.** (Ann. d. Physik, 65. 7. pp. 629–639, Sept. 27, 1921.)—This paper deals with the theory of Simpson and others on the breaking up of water drops in a thunderstorm by means of uprushing air; and with the author's waterfall theory of the breaking of drops in a waterfall. Figures are given showing Hochschwender's results in the disruption of falling water due to uprushing air. In 1/35 sec. a spherical drop passes into an inverted-cup shape and later bursts into small fragments. A table of results is also given showing how the diameters of drops varying from 2·5 mm. to 6·0 mm. decide what velocity of uprushing air is required to keep the drops in steady suspension, or, on the other hand, to break them up. The velocities for suspension range from 6·4 m./sec. to 8 m./sec. for sizes of drops quoted above, and the velocities for disruption vary from 20 m./sec. to 10 m./sec. P. E. S.

DISCHARGE AND OSCILLATIONS.

180. *The Photoelectric Theory of Flame Conduction.* **E. Marx.** (Ann. d. Physik, 65. 8. pp. 657–674, Oct. 13, 1921.)—In a previous communication [see Abs. 1375 (1916)] the author has shown that the ionisation of flames is chiefly dependent upon the setting free of electrons in metal atoms of the alkali flame. In this the photoelectric hypothesis was advanced in place of Lenard's explanation. The present paper is a theoretical one in which this line of argument is continued. A. E. G.

181. *Theory of Electrical Conductivity in Flame Gases.* **B. Kurze.** (Ann. d. Physik, 66. 2. pp. 133–154, Nov. 22, 1921. Extract of Dissertation, Leipsig.)—After a brief introduction, the experimental researches of various authors are discussed, and in the second half of the paper the theoretical basis of conductivity in flames is dealt with. It is concluded that by making use of vertical electrodes the electrical conductivity in flame gases can be dealt with just as if the gases were at rest, the flame motion having no influence. Only the edge conditions are altered by surface ionisation and the behaviour and condition of the electrodes have no influence on the inner flame. The currents in the flame are, from the standpoint of theory, considered as feeble currents. With small voltages the surface ionisation must be taken into consideration. The paper concluded with some remarks on the photoelectric theory of alkali flames. A. E. G.

182. *Importance of the Electric Wind for Induction Sparks.* **F. Trey.** (Phys. Zeits. 22. pp. 406–409, July 15, 1921.)—Three methods are given which make possible the observation of electric winds in a spark track. The importance of the electric wind for the occurrence of the sparks is discussed. [Errata, *ibid.*, p. 496, Sept. 1, 1921.] A. E. G.

183. *Existence of Homogeneous Groups of Large Ions.* **P. J. Nolan.** (Phys. Rev. 18. pp. 185–198, Sept., 1921.)—*Homogeneous Groups of Large Ions in Air.*—*The existence* of such groups, which seemed proved by previous work reported by the author and others, has recently been questioned by the negative results obtained by Blackwood. Hence further experiments have been made using the Zeleny method adopted by Blackwood instead of the McClelland method previously employed. The 30 curves obtained nearly all show two or more peaks or breaks corresponding to definite groups. These peaks came at the same places whether the ions were produced by bubbling the air through alcohol or by passing it over phosphorus. *The mobilities of the groups* agree with the values previously reported within 10 % or less: 0·050, 0·025, 0·018, 0·0075, 0·0042, 0·0025, 0·0013, 0·00067, 0·00033. Some evidence of intermediate groups was also obtained. *In explanation of Blackwood's negative results* it is suggested that since ions are constantly changing from group to group, definite peaks can be expected only if the time spent by each ion in the measuring chamber is relatively short. In Blackwood's experiments this time was from 9 to 150 secs., whereas it was only from 0·5 to 13 secs. in the experiment reported here. AUTHOR.

184. *Light Excitation by Electron Collision.* II. *Spectrum of the "Osglim" Lamp.* **R. Seeliger** and **G. Mierdel.** (Zeits. f. Physik, 5. 2 and 3. pp. 182–187, 1921.)—This paper gives the results of a spectroscopic study of the neon glow-lamp made by the Osram Co. The latest type of lamp for 220-volt circuits was used. This gives a reddish light, and its energy consumption is very small, making it very suitable as a light-source for certain purposes. Spectroscopic examination of the light given by the lamp showed the contained gases to consist chiefly of neon, with traces of He, Ar, and Hg vapour. No other gases were detected even with voltage exceeding the normal voltage. The intensity distribution in front of the kathode was studied, and the results for the lines of the elements mentioned above are shown graphically. Some interesting observations were made of the relative intensity of certain helium lines under different excitation conditions. A. W.

185. *Negative Canal Rays and Gas Mixtures.* **J. Koenigsberger** and **A. Rüttenauer.** (Phys. Zeits. 22. pp. 193–200, April 1, 1921.)—Theory is given relative to the motion of neutral, positive, and negative canal-ray particles for pure and for mixed gases. Experiments are described with mixtures of hydrogen and mercury vapour; these, to a first approximation, confirm the theory advanced, as regards the transfer function for H −, H +, and H neutral. The transfer function may be compared with the free path, which Reinganum has calculated for neutral atoms from the theory of gases, and for slow ions from Langevin's theory. The comparison shows that the neutral canal-ray atom has on the average a greater radius than that corresponding to the single-quantum path. The negative H ion loses an electron more easily than the neutral Hg atom. Negative H_2 was not observed. Its existence as ions is doubtful. The experimental work showed that the Hg atom exerts a strong influence on H + canal rays. A possible explanation of this is given. [See Abs. 785 (1919) and 1466 (1920).] A. W.

186. *Effect of an Electric Current on the Photoelectric Effect.* **A. G. Shenstone.** (Phil. Mag. 42. p. 596, Oct., 1921.)—Horton [Abs. 1924 (1921)] has criticised a previous paper by Shenstone [Abs. 1808 (1921)], and he ascribes the results obtained to the emission of gas by portions of the apparatus when slightly heated by the current passed through the bismuth, and the subsequent production of radiation and ionisation in that gas by the photo-electrons. Definite experimental evidence against this explanation is here given. A. W.

187. *Fall of Potential at the Electrodes in Gas Discharge Tubes.* **H. Schüler.** (Phys. Zeits. 22. pp. 264–268, May 1, 1921.)—The apparatus used is described and illustrated and numerical results of the experiments are given. The normal kathode-fall has been defined as the energy which is necessary to bring the positive ions out of the negative glow layer to the kathode, so that they by their collisions in the dark space may ionise the discharge gas and with it create the necessary electrons for the separate discharge. There exist simple relations between the ionising potential of the gas, the ratio of the mean free path of the electrons to that of the gas molecules, and the normal kathode- and anode-fall. There are recognised with Al, in hydrogen, two completely different, and, in the same gas, with Fe two further different discharge forms, so that the idea of normal kathode-falls of a gas in a metal is no longer unequivocal. Under special conditions the total voltage in a discharge tube is equal to the kathode-fall. The anode-fall is not a necessary condition for a separate discharge. Double dark spaces with the ionising steps 11·5/30·4 and 17·1/30·4 are found with hydrogen. The fall of potential at the electrodes depends only upon the constants of the gases; the constants of the metals appear to play no part. The action of the metal, or metallic vapour, always present in discharge tubes in consequence of sputtering, seems to be purely catalytic. A. E. G.

188. *Electron Collisions and the Striated Discharge in Mercury Vapour.* **W. Grotrian.** (Zeits. f. Physik, 5. 2 and 3. pp. 148–158, 1921.)—From the work of Franck and Hertz on the laws of motion and collision for slow electrons, in relation to the excitation of light by electron collisions, it can be theoretically predicted that greenish luminous layers should occur in mercury vapour when the electrons leaving an incandescent wire in the vapour are accelerated by an applied electric field. The research here described verified the theoretical considerations in all respects. In particular, the layer potential was found, within the limits of experimental error, to have the same value as the resonance potential of Hg vapour, 4·90 ± 0·05 volts.

Emission Bands in the Ultra-Violet.—Certain bands which have hitherto only been observed in the absorption spectrum of Hg vapour were also found in the emission spectrum. Seven bands were observed: (1) **λ2349** to **λ2341**, (2) **λ2339** to **λ2337**, (3) **λ2334**, (4) **λ2329**, (5) **λ2325**, (6) **λ2321**, and (7) **λ2317**. It is probable that with greater light-intensity still more bands would be visible. A. W.

189. *Ionisation in the Geissler Discharge.* **E. Rumpf.** (Ann. d. Physik, 66. 1. pp. 50–70, Oct. 27, 1921.)—A continuation of previous work [Abs. 297 (1918), 1230 (1919), and 1319 (1920)]. Methods are described for obtaining the ionic "density" and the recombination constants in Geissler tubes. The disappearance of ionisation was found, under given conditions, to depend only on the recombination of the ions, but the disappearance varies a good deal with the condition of the electrodes in the Geissler tube. The recombination constant for air at a pressure of 0·2 mm. of mercury was found to be $3 \cdot 5 \times 10^{-8}$. A. W.

190. *Spark Discharge in Nitrogen at High Pressures.* **G. Hammershaimb** and **P. Mercier.** (Arch. des Sciences, 3. pp. 356–378, July–Aug., and pp. 488–501, Sept.–Oct., 1921.)—The method employed was the same as that used by Guye and Mercier [Abs. 903 (1920)], but modifications were introduced to obtain greater accuracy and to reach higher potentials. The results obtained are given in numerous tables and diagrams. At pressures from 1 to 4 atmos. and for the same electrode distance up to 5 mm., the disruptive potential diminishes and tends towards a limit as the radius of curvature of the electrodes increases. The maximum of the curves representing the variation of the sparking potential as a function of the diam. of curvature appears to be reached for electrodes having a diam. equal to or less than 15 mm. For pressures of 10 atmos. and above and for the same electrode distance, large plane electrodes and spherical caps of large radius give, for relatively large electrode distances, disruptive potentials greater than small plane electrodes and spheres, although for electrode distances up to 1 mm., hemispherical electrodes of small diameter give disruptive potentials higher than those found with plane electrodes and spherical caps of large diameter. Paschen's law was verified in the case of small hemispherical electrodes of diam. 15 mm., with errors of about 3 %. For plane electrodes the law holds good up to 10 atmos. pressure for electrode distances above 1 mm. For still higher pressures the law is less applicable the greater the diam. of the electrodes, the less the electrode distance, or the greater the pressure. With electrodes of different shape the disruptive potential has a value intermediate to those found for a pair of each type mounted symmetrically. It appears probable, from a discussion of all the results obtained, that the differences between the measurements and the values which would exactly verify Paschen's law result from the non-uniformity of the field when two spherical caps of small diameter are used, and also from the uneven distribution of the ions which tend to diminish the disruptive potential, particularly when large plane electrodes are used very close together and at high pressures.

A. W.

191. *Electric Oscillations in Straight Wires and Solenoids.* **J. S. Townsend.** (Inst. El. Eng., J. 59. pp. 771–775; Disc., 775–779, July, 1921.)—The free electric oscillations of a system correspond to the mechanical oscillations known as normal modes of oscillation. In the free oscillations of a system having distributed capacity and inductance there is, in general, no exact relation between the frequencies of the normal modes of oscillation. It is possible to obtain a system in which these frequencies are nearly proportional to the numbers 1, 2, 3, and 4, as in a single wire or a pair of parallel wires. But with an ordinary oscillatory circuit consisting of a condenser of large capacity and an inductance coil, the lowest frequency depends on the capacity of the condenser, and is widely different from the frequencies of the other free oscillations, which depend on the capacity of the inductance coil and are very little affected by the capacity of the condenser. The series of free oscillations thus obtained is sometimes referred to as harmonic series, but it is much better to call them " free oscillations " or " normal modes of oscillation," and to apply the term " harmonic " only to the series in which frequencies of the components are exactly proportional to the numbers 1, 2, 3, 4, etc. Any system with distributed capacity and inductance has several normal modes of oscillation, and a free oscillation may take place in any of these modes independently of the others. Also, when the system is acted upon by an alternating force, a large resonating current is obtained when the force frequency coincides with that of one of the normal modes. In these respects the series of free oscillations differs completely from the series of harmonics which accompanies the fundamental oscillation maintained by means of a valve.

Lecher-wire Systems.—If the wires of a Lecher system are very long compared with the distance between them, the frequencies of the free oscillations are almost exactly in simple proportions, as the effects of the ends and of neighbouring conductors are small in these modes of oscillation where the currents are in opposite directions at opposite points of the two wires. A number of experiments have been made to find to what degree of accuracy the lengths of short waves may be obtained by parallel wires, as this method is much simpler than that depending on measurements of the capacity and self-induction of a closed oscillatory circuit. The short waves measured by means of the parallel wires may be tuned to coincide with the harmonics of a long-wave generator, and the wave-length of the fundamental oscillation may thus be determined in terms of the lengths of short waves. A simple short-wave generator is described, the fundamental of which may be measured by a pair of parallel wires. The wires employed were about 8 m. long and were stretched about 1 m. above the tables. A loop L was connected to one end of the wires for coupling to the short-wave generator. With waves from 5 to 15 m. long, resonating lengths of the wires may be determined to within a few mm. by using a small incandescent lamp to indicate the current in the bridge across the wires. Greater accuracy may be obtained by using a thermo-junction. For accurate measurements it is necessary that the system comprising the parallel wires should have no free mode of oscillation which is nearly in resonance with the short-wave generator when the bridging piece is removed.

For *long waves* a different procedure is adopted. If w be the wave-length of the fundamental of the short-wave generator, and W that of a long-wave generator, W will be an exact multiple of w when one of the harmonics is in tune with the short-wave generator. When W is fixed, and w is varied continuously, a series of m harmonics comes into tune as w passes from the value w_1 to w_2. W is then given by the quotient $mw_1w_2/(w_1 - w_2)$. W may also be determined by keeping w constant and counting the number of harmonics as W is increased from W_1 to $2W_1$.

Solenoids.—There is no exact relation between the frequencies of the free oscillations in a long solenoid [see Abs. 1816 (1921)], but these oscillations are interesting from an experimental point of view, and the distribution of the charge and current in the solenoid is easily demonstrated by means of simple apparatus. Experiments with a solenoid 227 cm. long, with 29 turns per cm. and a diam. of 5 cm. gave results in fairly good agreement with theory, the discrepancies (more marked with the longer waves) being due to the effect of the ends and the increase of capacity produced by neighbouring bodies. A. W.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

192. *Factors Affecting the Resistance of Sputtered Platinum Films.* **L. R. Koller.** (Phys. Rev. 18. pp. 221–235, Sept., 1921.)—*Resistance of Sputtered Platinum Films; Ageing in Vacuo and in Various Gases.*—The rapid decrease of resistance which occurs if a film is kept *in vacuo* after sputtering, is doubtless due to coalescence or agglomeration of the particles making up the film. In air, oxygen, and hydrogen, however, this ageing practically stops, probably because the adsorption of gas around the particles prevents further coalescence until the gas is removed by re-evacuation or by chemical means. This adsorption theory was tested in various ways and was found in accord with all the facts. Nitrogen and CO_2 are only slightly adsorbed. The *effect of heating* is to accelerate and further the ageing process but with prolonged heating the resistance reaches a minimum and then increases indefinitely. *Temperature coefficients of resistance* to 200° C. were measured for films previously aged at a higher temperature and were found to depend, like the resistance itself, more on the physical condition, as determined by heat treatment, than on the thickness of the film. The highest coefficient measured was 0·002 which is about 4/7 of that of platinum in bulk. Very thin films have negative coefficients.

Activation of Platinum by Sputtering.—Both the sputtered film and the kathode used in sputtering cause hydrogen and oxygen to combine at room temperature so rapidly that the film and the kathode may become very hot. AUTHOR.

193. *Variation of Resistance of Selenium with Temperature.* **S. Datta.** (Phil. Mag. 42. pp. 463–470, Sept., 1921.)—Experiments have been carried out to measure the temperature coefficient of electrical resistance of selenium with a view to deciding how far the special properties of selenium are attributable to the changes in conductivity caused by changes in temperature. The curve showing the relation between resistivity and temperature, plotted from the results now obtained, suggests that the variation of resistivity with temperature is expressible by an empirical equation of the ordinary type: $R_t = R_0 + bt + ct^2$. The constants b and c are not general constants for selenium, but depend on the annealing and the past history of the cell. The curves also show that whatever may be the initial resistances of the cells, their resistances (for cells of the same dimensions) beyond 130° C. very nearly coincide, and the total change of resistance from 130° to 170° C. is about 1/30 of that from 0° to 130° C. It is also remarkable that beyond 130° C. all time-lags disappear, as well as the light and voltage effects. No definite results were obtained for resistances between 170° C. and 217° C. (melting-point). In almost all cases the cells show a decrease in conductivity beyond 170° C. It is also shown experimentally that not more than 1/25 of the "light effect" is attributable to heat produced by light. A change of colour is found to take place at the same time as the change of resistance when crystals of selenium produced by the sublimation method are warmed. A modified theory of transformation is suggested to account for the various observations in connection with the heat effect. A. E. G.

194. *Conduction of Electricity and Diffusion in Solid Salts.* **G. Hevesy.** (Akad. Wiss. Wien, Ber. 129. 2a. No. 6. pp. 549–564, 1920. Comm. from the Inst. f. Radiumforschung.)—Solid salts frequently exhibit an appreciable conductivity at ordinary temperatures and especially in the warm state. In the present investigation only such compounds are styled solid salts whose crystal lattices are built of ions, i.e. in which the separate lattice points are occupied by ions and not by molecules; *e.g.*, arsenic trichloride, boron trioxide, and solid hydrochloric acid are not classed as solid salts. The decision as to whether a solid can be classified as above is afforded by Röntgen-ray methods or by conductivity in the molten state [see Abs. 98 (1921)]. Good-conducting melts are profoundly dissociated, and, since the fusion procedure itself is not one to increase dissociation, such conductivity points to the ionic structure of the crystal. The magnitude of the self-diffusion constant to be expected may be calculated from the conductivity, and this calculation is carried out in detail for a crystal of common salt. Data are also given for a large number of salts, and experimental details are included for determinations with lead chloride. The electrical conductivity of salt crystals is explained by the extreme elongations executed by the separate ions which are thus suitably environed for migration to other positions in the lattice. According to this view a self-diffusion is to be expected without the intervention of a field effect to occasion change of ionic position in the crystal. The velocity of this independent diffusion calculated from the conductivity measurements is exceedingly small at ordinary temperatures, and, in the case of rock-salt scarcely amounts to 3×10^{-18} cm.^{2} per day. With increase of temperature this diffusion rapidly increases corresponding to an exponential function. For the case of rock-salt, heated from compact condition to its salting-point, the positional change amounts to $0{\cdot}014$ cm.^{2}

per day, and for the case of lead chloride taken 30 deg. below its melting-point the rate is 0·027 cm.^{2} per day. For the case of lead chloride the positional change may be followed by means of radio-active indicators, and the experimental value of 0·029 cm.^{2} per day is in good agreement with that calculated from the conductivity. H. H. Ho.

195. *Thermoelectric Effects in Iron and Mercury Due to Asymmetric Heating.* **J. M. Benade.** (Phys. Rev. 18. pp. 199–205, Sept., 1921.) — *Thermoelectric Effect Due to Temperature Gradient Along a Constriction.* — (1) *Iron rod.* — Using constrictions from 0·5 to 4 mm. in diam. and from 0·5 to 1·5 mm. in length, electromotive forces were obtained with gradients of a few degrees per mm. large enough to be measured easily with a sensitive galvanometer. For each constriction the effect was found to be proportional to the temperature gradient. The fact that it decreased as the mean temperature was increased indicates that it is not an inverse Thomson effect. Moreover it depends on the dimensions of the constriction, being less for the smaller diameters. (2) *Mercury.*—By using two relatively large quantities of mercury connected through a pin-hole in an intervening sheet of mica, a temperature gradient of at least 600 deg. C. per mm. could be maintained in the constriction, but a high-sensitivity galvanometer failed to indicate any e.m.f. although according to Benedicks' conclusions [Abs. 147 (1920)] a deflection of over 50 divisions should have been observed. His results are explained as due to a true thermoelectric effect between the mercury and the slate tube containing it. (3) *In explanation* it is suggested that the effect is associated with the non-homogeneity produced by the mechanical stresses set up in the iron as a result of unequal thermal expansion and is not due merely to the flow of heat through the constriction. AUTHOR.

196. *Dielectric Constant and Refractive Index of Fluids.* **H. Isnardi.** (Phys. Zeits. 22. pp. 230–233, April 15, 1921.)—Measurements were made of the dielectric constant of ethyl ether at different temperatures, and the results are compared with the theory of Gans [Abs. 1288 (1916)]. The temperature range was from − 180° C. to 0° C., and Tangl's results for the range + 18° C. to + 160° C. are also used. The results show that the Lorentz-Lorenz relation, according to which $\{(\epsilon - 1)/(\epsilon + 2)\}/D$ should be independent of the temperature, is not even approximately correct, nor is the expression $\{(\epsilon - 1)/(\epsilon + 2)\}T/D$ a linear function of the temperature, as required by Debye's theory. Following out Gans's theory, formulæ are obtained for the dielectric constant in relation to the temperature and also for the refractive index in the visible region. The experimental results are found to be in good agreement with theory. Calculations of the dielectric constant and the refractive index of ether vapour are in close agreement with the experimental results of Bädeker and Lorenz. Other substances are being investigated. A. W.

197. *Distinction Between Intrinsic and Spurious Contact E.M.F.'s and Absorption of Radiation by Metals in Quanta.* **R. A. Millikan.** (Phys. Rev. 18. pp. 236–244, Sept., 1921.)—*Stopping potentials for photo-electrons from Na, K, and Li* surfaces, as determined with a Faraday cylinder *in vacuo* for monochromatic ultra-violet light, were found to be accurately the same for all. This result makes general the conclusion that the stopping potential for a given frequency is the same for all clean metals. It is not the same for an *oxidised copper surface*, however, or for any surface showing a spurious contact e.m.f.

Contact e.m.f.'s between Na, K, and Li and the oxidised Cu surface of a Faraday cylinder were not found to be constant, but their changes were found to keep pace exactly with changes in the common stopping potential. These changes are attributed to the entanglement of electrons in the copper oxide surface, thus giving rise to a spurious e.m.f.

Intrinsic contact e.m.f. between any two metals is shown to be a definite quantity equal to $(h\nu_0 - h\nu'_0)/e$, when ν_0 and ν'_0 are the threshold frequencies for photoelectric emission from the two metals. This equation enables intrinsic to be *distinguished from spurious contact e.m.f.* For if the observed contact e.m.f. differs from this value (which it does not do for clean metals), there is a spurious contact e.m.f. equal to this difference and also equal to the difference in stopping potentials.

The photoelectric quantity $h\nu_0$ is shown to be equal to the thermionic work function ϕe measured at the same temperature.

Theory of photoelectric emission.—Proof is adduced for the conclusion that either the free, conduction electrons of a metal have the power of taking up the energy $h\nu$ from the incident light, or that, as Barkla has claimed, absorption does not take place in whole quanta. The difficulties associated with each conclusion are pointed out. AUTHOR.

198. *Action of Electromagnetic Waves on Dielectric Hysteresis.* **E. Drago** and **G. Areidiacono.** (N. Cimento, 22. pp. 68–93 July–Aug., 1921.)—Describes experiments to determine the hysteresis in an ellipsoid of dielectric (sulphur and paraffin) oscillating between two discs attached to the plates of a condenser, and surrounded by a fine coil of wire forming part of an oscillating circuit. Experiments were also made with an ellipsoid containing 5 % of graphite. The logarithmic decrement of the oscillation of the ellipsoid was observed with the current on and off, and it was found to be slightly greater in the former case. J. W. T. W.

199. *Electrical Conductivity of some Dielectrics.* **H, H. Poole.** (Phil. Mag. 42. pp. 488–501, Oct., 1921.)—It has previously been shown [Abs. 1172 (1917)] that the conductivity of mica, instead of being independent of the gradient, as demanded by Ohm's law, rises rapidly with increase of pressure, the logarithm of the conductivity being nearly a linear function of the gradient. The experiments on mica have been repeated and other dielectrics have also been investigated, using a transformer and rectifying valves instead of the Wimshurst machine employed in the earlier work. The previous results for mica were generally confirmed, but it is shown that when the logarithm of the conductivity is plotted against the potential gradient over the considerable range used, the isotherms exhibit distinct curvature. In the case of the other dielectrics tested, the available range is much less, and the isotherms are approximately straight lines. Glass differs from mica, as in this case the slope of the isotherms decreases with rise of temperature. A. W.

200. *Measurement of the Dielectric Coefficient of Air; Valve Method of Determining Capacity Variation.* **E. W. B. Gill.** (Radio Rev. 2. pp. 450–454, Sept., 1921.)—Two separate valve-generator circuits are coupled loosely through an intermediate circuit having inductance and variable capacity. The currents induced in this latter circuit are rectified and amplified by a low-frequency amplifier. The intermediate circuit is tuned roughly to the wave-length of one generator. If the wave-length of the second generator is varied, the usual ascending and descending musical scale is heard in the telephones connected to the amplifier. This includes the inaudible interval. In place of the latter, it is found that as the note gets lower, a rattle is heard whose frequency decreases as the tuning continues, and it eventually vanishes, its vanishing-point being sharply defined.

By using this method, a *variation in capacity* of 1/80 cm. can be detected. In applying the method to the measurements in question, the condenser of one generator unit was placed in a vessel which could be evacuated. By keeping the wave-length of the generator constant, for different air pressures and equal temperature, using a small tubular condenser of calculable capacity variation, the dielectric coefficient of air can be found, that of a vacuum being taken as unity. The precautions necessary for accurate results are stated. N. W. M.

201. *A Valve Method of Measuring Frequencies.* **B. S. Smith** and **G. F. Partridge.** (Phys. Soc., Proc. 33. pp. 243–247; Disc., 247–248, June, 1921.)—Describes a method of measuring the pitch of musical notes, based upon the production of beats in two electrical circuits having valve oscillators, reception being by telephone. The calibration of the generator is described and curves are given. In practice, variation of beat frequency was measured by a condenser which does not require to be absolutely measured for intermediate values. A general discussion of the method ensued, and a demonstration was given of the production of a note of frequency 10,000, which was inaudible to a portion of the audience. B. J. L.

202. *Capacity and Eddy-Current Effects in Inductometers.* **S. Butterworth.** (Phys. Soc., Proc. 33. pp. 312–353; Disc., 353–354, Aug., 1921.)—1. A theoretical investigation has been made upon the effects of self- and intercapacities and of eddy-current losses in mutual inductances for which the coils have a common point. The following are the main conclusions arrived at:—(*a*) Small capacities introduce variations in the effective self- and mutual inductances which change as the square of the frequency. (*b*) Corresponding variations are introduced in the effective resistances of the coils. (*c*) The mutual inductance is no longer "pure," that is, the secondary e.m.f. is no longer in exact quadrature with the primary current. The primary and secondary circuits behave as if they have a resistance in common which varies as the square of the frequency. (*d*) Eddy currents produce impurity and changes of effective resistance which are initially of the same nature as those due to capacity. (*e*) Eddy current and capacity effects may be so combined that the variations of mutual inductance and of impurity cancel simultaneously, so that it is theoretically possible to obtain a "pure" mutual inductance having no variation with frequency over the whole range of audible frequencies.

2. The conditions of balance of three a.c. bridges, viz. (*a*) the Heaviside inductance bridge; (*b*) the Carey-Foster bridge; (*c*) a modified Campbell frequency bridge, have been worked out on the basis that the mutual inductance is not pure and the mutual and self-inductances are

not invariable with frequency. It is shown how combined observations on these bridges may be used to determine the frequency corrections of a given inductometer.

3. An experimental study has been made upon an inductometer of the Campbell type. The results show that if such an inductometer is used at the higher audible frequencies for the measurements of the effective resistance of coils or of condensers, the inductometer corrections may in certain cases be larger than the quantities measured.

4. A method for automatically correcting an inductometer is suggested in order that it may be used for the measurement of power factors of condensers without having recourse to tables of corrections.

AUTHOR.

203. *Valve Method for Determining Capacity.* **Karolus** and **[Prince] Reuss.** (Phys. Zeits. 22. pp. 362–363, June 15, 1921.)—A small transmitting valve or a receiving valve has its grid and filament connected together. The filament current is measured by an ammeter in circuit. The condenser, whose capacity is to be determined is included in the anode circuit, and a static voltmeter (a Wulf quadrant electrometer) is joined in parallel with it. A sensitive mirror galvanometer serves to measure the anode current. An anode voltage sufficient to give the saturation current in the valve is used; this voltage depends on the filament current; in the experiments here described anode voltages of 300 volts were used, the saturation voltage being about 30 to 50 volts.

The condenser is first short-circuited. On removing the short-circuiting connection the condenser accumulates a charge proportional to the time. The charging current will remain constant so long as the difference between the anode potential and the back e.m.f. of the condenser exceeds the saturation voltage. Measurement of the time t required for the anode current I_a to charge the condenser (of capacity C) to the measured potential V, allows C to be determined at once from the relation $C = I_a t/V$. The method can be used for widely different capacities. In the experiments here described the capacities varied from 0·01 to 1·0 microfarad.

A. W.

204. *Polar Representation of Current Curves.* **W. Geyger.** (Phys. Zeits. 22. pp. 360–362, June 15, 1921.)—An arrangement is described for obtaining photographs giving the polar diagram of alternating-current curves. For this purpose the plate is mounted on a disc which can be rotated by an electric motor. The disc rotates in a light-tight box, in the front of which a photographic lens with a rapid shutter is mounted. The distance of the lens from an oscillograph mirror is adjusted so as to give a sharp image on the photographic plate. The speed of the motor is adjusted to the frequency of the alternating current or to some definite fraction of it. A synchronous motor fed from the alternating current in question is, of course, preferable. When the motor speed is correct, the exposure is made, and a polar diagram is obtained on development. An alternative method with a fixed camera is described in which use is made of a rotating vacuum tube.

A. W.

205. *Eddy-Current Losses in Cylindrical Conductors ; A.C. Resistances of Short Coils.* **S. Butterworth.** (Roy. Soc., Phil. Trans. 222. pp. 57–100, Sept. 9, 1921.)—It is well known that a considerable proportion of the effective resistance of inductive coils when used at radio frequencies is caused by the eddy currents set up in the wires of the coils by the alternating magnetic field in which they are situated, and that in extreme cases the a.c. resistance may amount to more than one hundred times the d.c. resistance. It is therefore important to have reliable formulæ for the eddy-current resistance of such coils in order to determine the conditions which will reduce the eddy-current losses to a minimum. The simplest case, that of a long straight cylindrical wire under the action of its own current, has been treated by Kelvin, Rayleigh, Heaviside, and others. The case of two parallel wires forming a go-and-return circuit has been considered theoretically by Nicholson, and experimentally examined by Kennelly, who found that when the wires are close together, the added resistance due to the proximity of the wires may be of the same order as that due to the simple skin-effect. Nicholson's formula is very complicated and difficult to apply numerically. A formula is obtained for this case in the present paper, and is shown to agree well with Kennelly's observations. Stranded wires are often used instead of solid wires, the idea being that the sum of the eddy losses in the individual wires shall be less than the eddy loss in the corresponding solid wire. Lindemann verified this experimentally at certain frequencies, but also found that if a solid-wire coil and a stranded-wire coil are compared at various frequencies, the stranded-wire coil increases in resistance more slowly at the lower frequencies, but less slowly at the higher frequencies, until above a certain frequency the stranded-wire coil has a greater effective resistance than the solid-wire coil. In view of the extensive use of stranded wire in the construction of coils for high-frequency currents it is important that the limitations of stranded wire in reducing effective resistance should be known, and the present investigation includes the consideration of such coils. From the formulæ obtained, conclusions are drawn in regard to the utility of stranding, and in regard to what degree of stranding it is necessary to employ before any improvement over solid-wire coils may be expected.

The formulæ deduced in this paper differ from those already established in that: (1) The dimensions of the winding sections of the coils are small compared with the coil radii; (2) there is no limitation imposed on the frequency; (3) the wire is taken to be circular. In regard to (1) it is shown that coils of this type have better a.c. time-constants than long coils. In regard to variation with frequency, the factor governing the upper limit to the application of the square law for eddy losses is the magnitude of f/R_0, where f is the frequency and R_0 is the d.c. resistance per unit length of the wire used. If (in c.g.s. units) f/R_0 is less than 0·225, the eddy-current losses vary as $(f/R_0)^2$ to an accuracy of 1 %. At higher frequencies the variation is slower, the ultimate rate of variation being as $(f/R_0)^{\frac{1}{2}}$. A knowledge of these limiting rates of variation enables an immediate explanation to be given of Lindemann's results with stranded-wire coils. A solid wire in a given alternating field has eddy losses which are a function of $f/R_0 = \phi(f/R_0)$ say. If the solid wire is replaced by s strands of the same total metallic section, the loss per strand in the same field is $\phi(f/sR_0)$, and the total loss in the s strands is $s\phi(f/sR_0)$. Thus, as regards the losses due to the general field of the remainder of the coil, we must replace $\phi(f/R_0)$ by $s\phi(f/sR_0)$ in passing from solid to stranded wire. At low frequencies $\phi(f/R_0) = C(f/R_0)^2$, where C is a constant independent of the stranding, so that the respective losses are $C(f/R_0)^2$ and $Cs(f/sR_0)^2 = C(f/R_0)^2/s$. The effect of stranding at low frequencies is thus to reduce these losses in the ratio $1/s$. At high frequencies $\phi(f/R_0) = C'(f/R_0)^{\frac{1}{2}}$, and the losses are $C'(f/R_0)^{\frac{1}{2}}$ and $C's(f/sR_0)^{\frac{1}{2}} = C's^{\frac{1}{2}}(f/R_0)^{\frac{1}{2}}$, or the effect of stranding at high frequencies is to increase the losses in the ratio $s^{\frac{1}{2}}/1$. Since in inductive coils the general field produces the main losses, Lindemann's results are explained.

The different sections of the paper deal with: (1) Eddy-current losses in a cylinder in an alternating magnetic field; (2) Eddy-current losses in two parallel cylinders carrying equal currents; (3) Losses in parallel wire systems and in short coils; (4) Single layer solid-wire coils; (5) Single layer stranded-wire coils; (6) Multi-layer coils. A. W.

206. *New Alternating-Current Generator having an Unsymmetrical Voltage Curve.* **M. Breslauer.** (Elekt. Zeits. 42. pp. 1025–1029, Sept. 15, 1921.)—Describes an a.c. generator of a new design characterised by its giving a very unsymmetrical voltage curve, so that it is very suitable for the excitation of X-ray tubes, for which purpose it is primarily intended, and also for electrochemical purposes.

Previous methods utilised for the production of rectified high-tension currents, such as by means of Lodge valves, are described. The machine now developed is then dealt with. In this the asymmetrical properties depend fundamentally upon the fact that the air-gap between the rotor and stator is made excentric. Oscillographic results obtained from the machine as actually manufactured are given. Illustrations of the machine (which is apparently manufactured for relatively high outputs) as applied to high-tension work are also included. B. J. L.

207. *A New Form of Wehnelt Interrupter.* **F. H. Newman.** (Roy. Soc., Proc. 99. pp. 324–330, July 1, 1921.)—Experimental results obtained with the author's form of this interrupter [see Abs. 441 (1920)] are given. The author discusses the various explanations which have been put forward regarding the action of electrolytic interrupters. He adopts the view of Blondel that the high resistance causing interruption is due to the accumulation of oxygen liberated by electrolysis, and his results give the same results at high frequencies as Blondel obtained with lower frequencies. Oscillograms show the time of interruption to be small. The author concludes that probably the heat effect and electrolysis together account for the interruption. B. J. L.

208. *Reciprocating Expansion Apparatus for Detecting Ionising Rays.* **T. Shimizu.** (Roy. Soc., Proc. 99. pp. 425–431, Aug. 2, 1921.)—The investigation described was undertaken for the purpose of obtaining a very sensitive method of detecting and distinguishing the individual effects of ionising rays, such as X-rays and rays from radio-active substances. The author has accordingly developed an ingenious modification of C. T. R. Wilson's expansion apparatus [see Abs. 1885 (1912)], in which ionisation tracks are made visible by a cloud-condensation method. Details of the modified method are given; the apparatus described consisting essentially of a reciprocating expansion apparatus giving 2 or 3 expansions per sec. A commutator is arranged to establish and destroy an electrostatic field between the upper and lower surfaces of the condensation chamber in synchronism with the piston: this ensures a fresh set of tracks at each expansion. Arrangements are provided for examining the tracks either visually or photographically. In the latter case a stereoscopic kinematographic film arrangement is fitted to take photographs of the tracks at every expansion over a considerable interval of time. [See also Abs. 1826 (1921).] A. B. W.

209. *Detecting Efficiency of the Resistance-Capacity Coupled Two-Valve Amplifier.* **E. O. Hulburt.** (Phys. Rev. 18. pp. 165–177, Sept., 1921.)—*A theoretical formula* is derived and compared with the results of *measurements* made by using a condenser potential divider to vary the high-frequency input voltage A and a sensitive galvanometer to measure the rectified high-frequency component of the output plate current b_0, the detecting efficiency being defined as b_0/A^2. Satisfactory agreement was found for the *various frequencies and coupling capacities* tried. The *effect of a third tube* was determined experimentally. For convenience of *comparison with transformer-coupled amplifiers*, curves are given showing the detecting efficiencies of the various amplifiers as a function of the frequency and hence their relative merits in detecting unmodulated signals.

The *current amplification of the above amplifier as a function of the frequency* was also determined. [See Abs. 132 (1921).] AUTHOR.

ALTERNATING CURRENTS AND MAGNETISM.

210. *Thermodynamics of Magnetisation, and Magneto-Frigorific Cycles.* **A. Perrier.** (Arch. des Sciences, 3. pp. 533–536, Sept.–Oct., 1921. Paper read before the Soc. Suisse de Physique.)—Certain correlations are stated as existing between the compressibility of fluids and magnetisation of bodies, namely, density and magnetisation, pressure and applied field, internal pressure of van der Waals and molecular field of Weiss. Other correlations are given which facilitate the physical interpretation of the thermodynamic equations of magnetisation. Among others is given the magneto-caloric effect as correlative to the polarisation of the Joule-Kelvin effect in fluids. Finally the principle of continuous-working magneto-frigorific machines is given, consisting of theoretical irreversible cycles in which heat is transferred from the cold body to the hot body. G. E. A.

211. *Note on the Formula of Langevin for the Susceptibility of Paramagnetic Bodies.* **W. Alexandrow.** (Phys. Zeits. 22. pp. 258–259, May 1, 1921.)—In the derivation of the Langevin expression for susceptibility it is usual to neglect the kinetic energy of the magnetic doublet since it has no effect on the average moment. The author gives the outline of a method of deducing the susceptibilities from the expression for the total energy of the doublet. The result is obtained that only molecules whose total energy is negative affect the average moment. L. L.

212. *Effect of the Rate of Cooling on the Magnetic Properties of an Annealed Eutectoid Carbon Steel.* **C. Nusbaum** and **W. L. Cheney.** (Bureau of Standards, Bull. 17. pp. 65–78 [Sci. Papers, No. 408], 1921.)—This paper discusses the results of a study of the effect of the rate of cooling upon the magnetic and other properties of an annealed eutectoid steel. In carrying out the experiment, six specimens of this steel were selected, heated to 800° C., and allowed to cool at various rates—one in air, another in lime, and the remainder in the furnace at slower and slower rates. The following properties were then measured: Normal induction for ordinary and large magnetising forces, residual induction, coercive force, resistivity, and Shore scleroscope hardness. In order to study the metallographic structure of the steel, micrographs of each specimen were made at a magnification of 500 diameters.

A study of the experimental results show that as the cooling rate is diminished there is a pronounced increase in the value of the max. induction for a given small magnetising force, a decided increase in the max. permeability, but a decrease in the coercive force. The values of the coercive force agree very well with the scleroscope hardness number.

In plotting the reluctivity line as calculated from the magnetisation curve, it is found that the reluctivity line consists of two straight lines with the bend occurring at a definite point. As the structure of the steel changes from an essentially sorbitic one to "divorced" pearlite, there is a gradual shifting of this bend toward the origin and a greater difference between the values of the "real" and "apparent" values of the saturation intensity of magnetisation as calculated from the slopes of the reluctivity line. AUTHORS.

213. *Connection between the Magnetic State of Iron and its Photoelectric Properties; Negative Experiments.* **J. H. J. Poole.** (Phil. Mag. 42. pp. 339–351, Sept., 1921.)—The electrons present in the atom are classified as (1) nuclear, (2) free or conducting, (3) dispersional or emissive, (4) valency and (5) photoelectric electrons. In ferromagnetic bodies there are also revolving electrons. It is highly probable that these classes are not mutually exclusive, and there are reasons for considering that classes (4) and (5) are identical. An attempt is made to obtain evidence that the photoelectric and magnetic electrons are the same. Light from a carbon arc was projected on to the end surface of an electromagnet core, and the total ionisation current from the surface to a copper gauze grid a few mm. in front of it was measured with a tilted leaf electrometer. The results of several series of observations indicate that magnetisation has no effect on the total number of electrons emitted by the illuminated surface. G. E. A.

214. *Determination of the Permeability of Paramagnetic Substances by the Bridge Method; Confirmation of Wiedemann's Law.* **G. Falckenberg.** (Zeits. f. Physik, 5. 1. pp. 70–76, 1921.)—A modification of the bridge method described by Heydweiller in 1903 has been used to measure the susceptibility of certain aqueous solutions. The inductance change is measured when a vessel containing the solution is placed within the coil of one inductance arm of the bridge. To increase the sensitiveness, high-frequency current, obtained by the aid of valves, replaced the intermittent direct current used in the earlier type of bridge. Adjustment to minimum in the telephone was made by means of a variable inductance in the second bridge-arm, movement of sliding contacts being avoided. Capacity effects due to the observer were eliminated, observations being made at a distance of 2 m. from the bridge. The maximum field was 10 c.g.s. units and the frequencies employed were 1000 and 12,000. For aqueous solutions of $Mn(NO_3)_2$, $CoCl_2$, $NiCl_2$, and $FeSO_4$ the results obtained confirm the Wiedemann law that the magnetisation of a salt is proportional to the quantity dissolved in unit volume. Phillips' measurements made in 1914 do not conform to this law. The law does not hold for $FeCl_3$. L. L.

215. *Thermal Variation of Magnetisation of Anhydrous Salts and Oxides.* **P. Théodoridès.** (Arch. des Sciences, 3. pp. 5–54, Jan.–Feb., and pp. 137–163, March, 1921.)—The complete paper corresponding to Abs. 537, 538 (1921).

216. *Magnetic Observations during Solar Eclipse, May 29, 1919. First Summary.* **L. A. Bauer.** (Terrest. Magn. 25. pp. 81–116, Sept., 1920.)—Previous observations though accordant require as much confirmation as can be obtained. [See Abs. 929 (1920) and Abs. 698 (1921).] The effect of the interposition of the moon appears to be similar to that of night in the diurnal variation. Reference is made to observations at previous eclipses, May 28, 1900; May 18, 1901; and June 8, 1918, and the conclusions drawn by van Bemmelen, Chree, and others. On the present occasion data were collected from observations both within and beyond the region when the eclipse was total or partial. The author summarises what appear to be the eclipse effects, and finds that they continue for some time after the end of the eclipse. For stations inside the totality belt the amplitude of the long wave in declination averaged one minute of arc, and the short wave half this amount. Similar effects were noted in the horizontal component, but the max. effect in either is only of the order of one ten-thousandth of the average magnetic field.

The actual results are tabulated from Mauritius, Dehra Dûn, Coimbra, Azores, Buluwayo, Pilar, Tortosa, Lukiapang, Apia, Antipolo, De Bilt, Rude Skov, and Valencia, but more are to follow. W. W. B.

RADIOGRAPHY AND ELECTROPHYSIOLOGY.

217. *Ionisation Apparatus for Radiological Measurements.* **Solomon.** (Comptes Rendus, 173. pp. 34–35, July 4, 1921.)—Deals with an apparatus consisting of a gold-leaf electroscope and a variable capacity, designed to permit of the easy measurement of dosage, within and outside the body, without the occurrence of discrepancies due to absorption by the tissues and by air surrounding the electroscope. The construction of the apparatus is described (without illustration) in detail. Calibration of the instrument is carried out by means of a known quantity of radium, as charge and capacity measurements are useless. B. J. L.

218. *A New Type of Stabiliser for use with the Coolidge Tube.* **W. K. Kearsley, Jr.** (Gen. El. Rev. 24. pp. 864–866, Oct., 1921.)—The variations of current through a Coolidge tube depend chiefly upon small quantities of gases liberated in the tube and variations in the voltage of the supply, which latter, for reasons of convenience in medical practice, is obtained from the mains rather than from accumulators as originally used by Coolidge in 1913. The ideal stabiliser is one which will immediately check any change of milliamperage due to either factor.

The device utilised is shown in the Fig., A being an electromagnet connected directly in the high-tension circuit. All the high-tension current passes directly through this magnet. B is an iron armature free to vibrate when current passes through the magnet A. C and D are contacts, one fastened to armature B and the other in series with the tube filament. A resistance R is connected across the contact leads, and S is a spring which pulls the armature away from the magnet and is capable of adjustment to give the desired current through the tube. Assuming a small current is allowed to flow through the tube and magnet A, this current exerts a pull on the armature B, but if the spring S is sufficiently strong the armature will not move. If the current is now increased the magnet overcomes the tension of spring S and the armature moves towards the magnet. The instant the armature moves, the contacts C and D separate and the filament current has to pass through the small resistance R, which lowers the filament current and so controls the high-tension current through the tube.

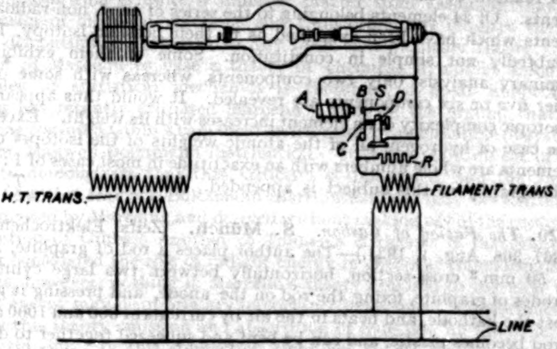


Diagram Showing Stabilizer in High-tension Circuit

An alternative form of apparatus where the control is directly operated via a transformer from the low-tension mains is also shown and the actual apparatus illustrated. The utility of the device is illustrated by means of a combined oscillogram of filament and high-tension current, and by numerical tables. B. J. L.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

219. *Isotopy of the Elements.* **R. Brunetti.** (N. Cimento, 22. pp. 5–42, July–Aug., 1921.)—The author discusses the question of isotopy in its relation to the atomic theory and to the periodic system of the elements. Of 24 elements belonging to the series of inert, non-radioactive elements which have been examined as to their possible isotopy, 12 are undoubtedly not simple in constitution. Some of them exhibit, on preliminary analysis, only two components, whereas with some of the heavier five or six components are revealed. It would thus appear that the isotopic complexity of an element increases with its weight. Excepting in the case of hydrogen, all of the atomic weights of the isotopes of the 24 elements are whole numbers with an exactitude in most cases of 1 : 1000. A bibliography of this subject is appended. T. H. P.

220. *The Fusion of Carbon.* **S. Münch.** (Zeits. Elektrochem. 27. pp. 367–368, Aug. 1, 1921.)—The author places a rod of graphite, 5 cm. long, 50 mm.^{2} cross-section, horizontally between two large cylindrical electrodes of graphite, fixing the rod on the anode, and pressing it gently against the kathode, and heats in the air by currents of 800 and 1000 amps. The rod becomes plastic, and can be bent and squeezed together to double the thickness ; it then catches fire, and drops of carbon fall into a ring-shaped cup surrounding the rod near the kathode gap, where the fusion takes place. Heat insulation and exclusion of the atmosphere are not attempted, and no analyses are given. **E. Ryschkewitsch** (*ibid.* pp. 368–369, Aug. 1, 1921) comments on the above. [See also Abs. 1317 (1921).] H. B.

221. *Separation of Chlorine into Isotopes.* **W. D. Harkins.** (Nature, 108. p. 209, Oct. 13, 1921.)—The paper refers to the preparation of 20 gm. of chlorine which has an atomic weight higher by 0·0375 unit than that of ordinary chlorine, and 80 gm. with an atomic weight higher by 0·034 unit, together with several kilogrammes the atomic weight of which has not been determined, but must be more than 0·02 unit high [0·2 in original is probably a misprint] in order to give the above results. The object up to the present has been to collect a considerable amount of material for future work, rather than to get the maximum increase of atomic weight. The atomic weight method used gave results accurate to 0·003 unit of atomic weight, and consisted in determining the amounts of acid in samples of ordinary and isotopic hydrochloric acid of the same density. A. B. W.

222. *Statistical Mechanics and Chemistry.* **E. P. Adams.** (Am. Chem. Soc., J. 43. pp. 1251–1254, June, 1921.)—Recently many attempts have been made to apply the quantum theory to problems of chemical dynamics. Some of these applications have made use of a quantum theory in a rather more definite form than has been found necessary in the physical applications, where the theory has had much success. If the laws of chemical dynamics are found to be consistent with the principles of statistical mechanics, it would seem to be not only unnecessary, but unjustifiable, to introduce the quantum theory in order to derive these laws. That the quantum theory is of importance in general chemical theory is probable; neither statistical mechanics nor the first two laws of thermodynamics give any information as to the constants which enter into the various thermodynamic functions. These constants depend upon the behaviour of systems at or near the absolute zero of temperature, and it is in this region that the quantum theory has had considerable success. But this is quite a different matter from assuming that the mechanism of chemical reactions and transformations requires the use of the discontinuities inherent in any form of a quantum theory. The attempt of Marcelin to base a theory of chemical dynamics upon the principles of statistical mechanics is therefore of great importance. Tolman has recently criticised Marcelin's work on the ground that the latter has confused Gibbs's canonical distribution of an ensemble of systems with the Maxwell-Boltzmann distribution. It is the main object of this paper to demonstrate that this criticism is unfounded, and the author shows how the Maxwell-Boltzmann distribution law may be written in the form used by Marcelin, and derived without making use of the canonical distribution of Gibbs. Another of Tolman's criticisms is that Marcelin has not considered the rôle of radiant energy in chemical transformations. There is, however, nothing in Marcelin's theory opposed to the view that radiant energy may be of primary importance in chemical transformations, since in this theory emission and absorption of radiation by the molecules are continuous. In this connection Bohr has shown that in the region of long wave-lengths the frequencies of emission of radiation may be determined by the principles of ordinary dynamics and electrodynamics, without the use of any quantum hypothesis. If the general validity of Marcelin's argument be admitted, it would appear that the frequencies effective in ordinary chemical transformations lie within the region of the long wave-lengths. H. H. Ho.

223. *Reaction between Incandescent Tungsten and Naphthalene at Low Pressures.* **M[ary] R. Andrews** and **S. Dushman.** (Frank. Inst., J. 192. pp. 545–546, Oct., 1921.)—Naphthalene $C_{10}H_8$ is decomposed by incandescent tungsten above 1500° K., but the rate of diffusion of the carbon into the tungsten only becomes more rapid than the decomposition of the naphthalene, at the low pressures used of 0·1 to 3·0 bar, above 2300°. By analysing the filaments and by measuring the hydrogen evolved the authors determine the carbon content. The electric conductance of the tungsten at room temperature decreases to 7 % of its original value as the carbon absorbed rises to 3·16 % corresponding to W_2C. On further carbonisation the conductance increases to 40 % of its original value at 6·1 % of carbon, corresponding to WC. The difference between the resistivity of the carbonised filament and that of pure tungsten seems to be constant at all temperatures up to 2400° K. It is said that both the carbides decompose near 2700° K., and that they have melting-points, W_2C at 3150° and WC at 3050° K. H. B.

224. *The Photochemical Equivalent and the Photographic Dry-plate.* **J. Eggert** and **W. Noddack.** (Preuss. Akad. Wiss. Berlin, Ber. 39. pp. 631–635, 1921.)—Assuming the photochemical action on the AgBr to be: $AgBr + h\nu = Ag + Br$, one atom of Ag should correspond to each quantum, according to Einstein. Agfa and Schleussner plates are used. Light of $\lambda 407 \cdot 8$ (Hg-vapour lamps filtered through copper-ammonia solution) acts for ½ hour to 2 hours; the energy is determined by the aid of a Rubens thermopile; the reduced silver (up to 0·5 mgm.) is dissolved in nitric acid (after removal of the AgBr by means of sodium thiosulphate), and determined by titration after Volhard. Thus the number N of Ag atoms is determined, and the number of quanta, Q, received is deduced from energy, λ, and length of exposure. The quotient $a = N/G$ represents the fraction of the radiation that has photochemically been active. a was found to be fairly constant (3 per cent.) for the same kind of plate, and the same ν. The absorption could further approximately be determined from photometric measurements of the unexposed plate. Light of the same λ was sent through 2 slits, 2 prisms, and 2 mirrors to the halves of a photometer R; the plate was then placed in front of the one slit, and the one mirror was adjusted until equality was restored in R; that gave the light transmitted by the plate. R was then replaced by a plate consisting of an upper and a lower half, so as to compare the reflected and the transmitted portions. In this way the reflected light was found to vary between 42 and 62 per cent., the transmitted between 53 and 26, the absorbed between 4 and 11·4 per cent.; the last figures of a pair concern the special Agfa plates. More exact measurements are being made. As regards the relation between quanta absorbed and grains of AgBr decomposed the ratio calculated/measured was 280, *e.g.*, so that several hundred quanta might be thought to act on one grain of bromide. But there are vast interstices between the grains, and the decomposition is probably confined to the surface. The conclusion drawn is that every grain of silver corresponds to one quantum, and only to one. H. B.

225. *Oxidation and Luminescence of Phosphorus.* III. *Catalytic Action of Vapours.* **H. B. Weiser** and **A. Garrison.** (J. Phys. Chem. 25. pp. 349–384, May, and pp. 473–490, June, 1921.)—Further experimental results indicate that, with the exception of a trace of water-vapour, vapours which influence the rate of oxidation of phosphorus are not catalysts in the ordinary sense of the term. These vapours are merely condensed on the electrically charged or uncharged oxidation products—the trioxide and pentoxide. If the vapours are capable of reacting with phosphorus trioxide, they increase the rate of oxidation, whereas if they are inert they prevent further oxidation of phosphorus trioxide, and also form a cloud near the surface of the phosphorus. This cloud approaches the surface more and more closely as the oxidation becomes less and less energetic, and may form a protecting film which reduces vaporisation and oxidation of the phosphorus to a minimum. T. H. P.

226. *Effect of Temperature on the Shape of the Surface Layers of Crystalline Selenium.* **W. S. Gripenberg.** (Phys. Zeits. 22. p. 281, May 1, 1921.)—During the preparation of selenium plates by the crystallisation of molten Se between glass plates at a constant temperature of 190° C. it happened that during the cooling process the initial highly lustrous, smooth selenium surface became perceptibly uneven. This is apparently due to a partial granular structure of the original smooth surface. The interference effects between the selenium and glass are described, and it was found that these could be repeated at will according to the temperature variation scheme employed. Closer investigation showed the selenium surface to be covered with numerous dimples, of 0·1–0·001 mm. diameter, corresponding to crystal individuals. The chief crystal axis appears to be perpendicular to the glass surface, and the cause of the dimples seems to be that the coefficient of thermal expansion has its greatest value in the direction of the main axis. The phenomenon occurs most distinctly when crystallisation takes place at the highest constant temperature possible. The author opines this result to throw fresh light on the mechanism of the action within selenium cells. He deduces that for a fixed temperature, the union between selenium and electrode has a certain degree of completeness which no longer holds for other temperatures, since the selenium surface varies and changes thereby the junction resistance. This phenomena also explains the impossibility hitherto found of making accurate measurements with selenium. H. H. Ho.

227. *X-ray Analysis of Three Series of Alloys.* **M[ary] R. Andrews.** (Phys. Rev. 18. pp. 245–254, Sept., 1921.)—*The crystal structure of three series of alloys* has been determined by Hull's method of X-ray analysis, using sheets of collodion or zapon in which the filings or powders to be investigated were embedded.

The *Fe-Ni and Fe-Co series* of pure binary alloys were each found to be solid solutions of one metal in the other with a single region of transition at 22–30 % Ni and at 80–90 % Co respectively. This means that Fe atoms can be substituted for up to 70 % of the Ni atoms in the face-centred Ni lattice and Co atoms can be substituted for up to 80 % of the Fe atoms in the cube-centred Fe lattice without changing the crystal structure. No evidence of a compound Fe-Ni was obtained.

Fe-Ni alloys develop the cube-centred form when made magnetic by chilling in liquid air.

The *Cu-Zn series* of alloys form solid solutions of Zn in Cu up to 47 % Zn, then change first to the cubic, then to the rhombohedral, and finally to the hexagonal form typical of Zn. These changes correspond roughly with changes in the hardness curve. The *effect of annealing* was not appreciable. AUTHOR.

228. *Woody Fibrous Fractures in Steel.* **E. H. Schulz** and **J. Goebel.** (Stahl. u. Eisen, 40. pp. 1479–1485, Nov. 4, 1920. Rev. de Mét. 18 E. pp. 423–425, Aug., 1921.)—Fractures of rolled steel and of pressed steel sometimes show a peculiar fibrous feature, reminiscent of wood fibre; the strength of such materials at right angles to the fibre is low; thermal treatment does not improve the steel. Oberhoffer (*ibid.* pp. 705 and 872) ascribed the peculiarity to the secretions of phosphides and sulphides, and to slag enclosures, which would appear in parallel lines on rolling. Kühnel (*ibid.* 38. p. 1173, Dec. 19, 1918) traced the trouble back to pipe and blowholes, pointing out that there had been internal cracking before the fracture. The authors suggest that neither explanation fully meets the cases. They found in a rolled rod a core of decidedly fibrous texture, distinct from the steel around it, which was also fibrous, however; the material on both sides of the boundary had the same composition, but in the core less carbon and silicon were found, the other constituents being unaffected; the core seemed to be a lump of softer material, which had not coalesced with the bulk of the steel. Numerous other cases are illustrated and discussed. An axially-drilled rod had split longitudinally, showing parallel fibres across the cleft, which had edges serrated in step fashion. It is also pointed out that when a punch is forced into steel, the lines of flow are concentrated below the face of the punch, and that a kind of slip cone is formed there, which may subsequently, on crushing the specimen, break out, especially when slag is disseminated through the steel. H. B.

229. *Artificial Colouration of Crystals Obtained by the Solidification of a Molten Substance, and Crystalline Diffusion.* **P. Gaubert.** (Comptes Rendus, 172. pp. 1299–1301, May 23, 1921.)—The paper indicates further instances of true colouration, due to the formation of a solid solution, as exemplified in a previous note by the author [see Abs. 653 (1919)], by means of the addition of a colouring matter to the molten substance, afterwards allowed to crystallise. The possible formation of eutectic mixtures is referred to. It is stated that indophenol or Java blue can colour crystals of vanilline, heliotropine, nitrochlorbenzene, and a number of other substances, by the introduction of the colouring matter to the fused substance, the results obtained being identical with those observed when the crystals are produced from a coloured mother-liquor, after taking the physical characteristics of the crystals into account. The diffusion of the colouring matter through the crystalline network is described and discussed. The phenomenon is ascribed to supersaturation. A. B. C. L.

230. *The Activity Coefficient of Strong Electrolytes.* **G. N. Lewis** and **M. Randall.** (Am. Chem. Soc., J. 43. pp. 1112–1154, May, 1921.)—After discussing various methods of determining the exact values of the activity coefficient (thermodynamic degree of dissociation), the authors have shown that the activity coefficients of sodium chloride (0–6 M), calculated from freezing-points, agree with those calculated from electromotive force within a few tenths of 1 %, notwithstanding the fact that one term alone in the freezing-point equation, which involves the heat of dilution, affects some of the results by 20 %. An even more extensive test of the several methods is furnished in the case of sulphuric acid, where satisfactory agreement was obtained over the range from 0 to 20 M (66 % H_2SO_4) by three different methods.

Calculations of activity coefficients in mixtures, especially from the solubility of salts in the presence of other salts, lead to an extremely powerful and general rule based upon the new concept of *ionic strength*. Each ion contributes to this ionic strength by an amount which is proportional to its stoichiometrical molality multiplied by the square of its valence. In accordance with this rule the activity coefficient of every strong electrolyte (and the individual activity coefficient of every ion) is the same in all dilute solutions of the same ionic strength. It therefore depends in no way upon the number or the nature of the ions of which the solution is composed.

The general problem of the dissociation of strong electrolytes is discussed from several standpoints. AUTHORS.

231. *Chromogenetic Properties of Sulphur and Certain other Elements.* **O. C. M. Davis** and **F. W. Rixon.** (Phil. Mag. 42. pp. 259–262, Aug. 1, 1921.)—From various observations of different authors it would seem that the colour of a compound of two elements, in addition to the determining effect of the nature of the elements themselves, may possibly be associated in a measure with the energy of combination, more particularly with the energy which is left unabsorbed from the gross energy of the system and which may be termed the residual energy. That this is the case is indicated by a comparison between the normal potentials of the various metals and between the heats of formation of the compounds. With the oxides colour appears with those members having the lower heat of formation and similarly with the sulphides, but a colourless oxide often has a corresponding but coloured sulphide with a smaller heat of formation. From a table given it is seen that oxides having heats of formation over 70 are colourless, the corresponding limit for sulphides being about 40; further, oxides and sulphides having heats of formation of about these values develop colour when heated, *e.g.*, ZnS, ZnO, Sb_2O_3. Thus, high residual energy of the molecule leads to production of colour. Reference is made to other evidence in support of this view.

Such a connection between energy and colour has been instanced by Baly [Abs. 1175 (1920)], who has developed the idea that molecular frequencies are definitely related to the frequencies of the combining atoms and has made calculations for several illustrative examples on the basis of the quantum theory. T. H. P.

232. *Polarity of a Platinum Cell; Action of the Electrolytic Detector.* **F. Streintz.** (Phys. Zeits. 22. pp. 260–264, May 1, 1921.)—If the action of the electrolytic platinum cell (Pt in sulphuric acid) as wave-detector be due to polarity, there should be polarity also in the ordinary galvanic platinum cells. By experiments similar to those made with Al cells [Abs. 185 (1921)], the author and Fiala show that this is so, and that the polarity of Pt can be ascribed to the formation of a condenser with anodic current direction, as with crystals and Al electrodes. The cell contains Pt electrodes, wires and foil in various conditions, and outside them charged lead-accumulator plates. When the hydrogen is discharged on the Pt, the kathodic current i_{21} is the stronger; when oxygen is deposited the weaker anodic current is observed. If the unipolarity $U = (i_{21} - i_{12})/i_{21}$ and V the charging potential, then the efficient polarity UV is constant when V exceeds 8 volts. The relations hold only within limits, however, and certain obscure surface conditions of the electrodes are in the way of fixing definite rules for the current intensities in the two directions. H. B.

233. *Depolarisation by Light.* **E. Baur.** (Zeits. Elektrochem. 27. pp. 72–77, Feb. 1, 1921.)—The author believed that light depolarises substances E, *e.g.*, colouring matters, sensitive to light, in the sense of Staechelin (Zeits. Phys. Chem. 94. pp. 542–591, 1920) by a (generally concealed) photolysis of water. The molecule E is polarised by absorption of a quantum of light, and enabled to bring about a molecular electrolysis. The primary phototropic effect yields $E^{\oplus}_{\ominus}$; a potential difference is set up in the molecule capable of doing external work; thus $E\begin{matrix}\oplus + OH' = \frac{1}{4}O_2 + \frac{1}{2}H_2O \\ \ominus + H^{\cdot} = \frac{1}{2}H_2\end{matrix}$, i.e. the dark condition is reached by a photolysis liberating electrolytic gas (H_2, O). This gas need not be visible, because the reverse reaction takes place also, i.e. the OH' (and the $H^{\cdot}$) and the terms on the right side of the equation changing places. The experiments after Staechelin are made with trough cells containing aqueous solutions of uranyl sulphate, eosin, quinine sulphate, etc., and platinum gauze electrodes, which are polarised by accumulators and illuminated by rays from a half-watt lamp (heat rays filtered off); potential curves are taken for anode and kathode separately. The liquids are stirred, and it is observed that the electrodes need not themselves be illuminated. That H_2, O can depolarise both a Pt kathode and an anode is shown by special experiments. To render the generation of H_2, O gas visible, the author makes use of a peculiar arrangement. Two inverted glass bells are placed in the trough and are joined in inverted Y fashion to a graduated tube; the electrodes in the two bells are loose masses of very fine silver-gilt wire (6 m. of wire); there is thus little liquid, but a very large electrode surface; the whole device is rocked to and fro. Some gas was collected during the experiments; but it was in most cases far less than would have corresponded to the currents observed, and the generation stopped after the first few illuminations; the gas may only have been air. The currents were surprisingly large. H. B.

234. *Electrolytic Separation of Copper, Antimony, and Tin; White Metal.* **F. Foerster** and **D. Aanensen.** (Zeits. Elektrochem. 27. pp. 10–16, Jan. 1, 1921.)—In 1908 and later Schürmann and Arnold [see Abs. 292 (1910)] described an electrolytic method of analysing white metals, replacing the former method of distillation in a current of chlorine. The chief points were that, in the presence of both nitric and tartaric acids, copper could alone be deposited, and that in the tin analysis it is better to have the oxalate solution alkaline than acid with oxalic acid. The method, and especially the latter claim, was criticised by Foerster at the time; he now withdraws his criticisms on the strength of an investigation conducted by Aanensen, and also of other researches published. From the solution in nitric and tartaric acids copper is deposited until the red copper begins to turn black with antimony; the precipitate is afterwards re-dissolved and treated in the same way, and the electrolyses may then be prolonged without any of the little antimony now present being deposited; when the copper percentage is approximately known, the analysis can be stopped after the time necessary for the deposition of the copper. For the determinations the antimony is precipitated by H_2S, from alkaline oxalate, and the tin is then electrolytically deposited at 80°, the solution having been rendered alkaline with caustic potash and oxidised with hydrogen peroxide; the alkali and the water evaporating are replenished. As the Pt kathode may alloy with the tin it is profitably covered with a layer of copper. The paper discusses special experiments; it does not describe the technical analysis. H. B.